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ABSTRACT

Major aspects of the management of the physical plant of campuses are considered in 42 chapters. The five major sections cover: personnel services; budgeting and accounting; maintenance management; plant operations; and planning, design, and construction. A conclusion describes proven methods and criteria for self-evaluation of the physical plant. Chapter titles and authors include the following: "Recruitment and Employment Practices" (Susan Jackson, H. R. Patterson, Jr.); "Employee Relations" (Patrick Cunningham); "Training and Development" (Jack Hug); "Formula Budgeting as a Technique" (William S. Gardiner); "Zero-Base Budgeting as a Technique" (Ronald R. Blickhahn); "Maintenance Management Systems" (Michael D. McGough, David J. Gojdics, Edward B. Phillips); "Preventive Maintenance" (Michael J. Dwyer, Jr.); "Grounds Maintenance" (Dean A. Ramsey, Denise M. Candelari, James D. Long); "Custodial Services" (Kirk Campbell); "Building Mechanical and Electrical Systems" (Robert Hascall, Larry Johnson); "Energy Management and Conservation" (Joe J. Estill); "Computerization of Plant Operations" (Earl W. Hawkey); "Campus Master Planning" (Harley A. Schrader, Richard R. Williams); and "Design Phase" (Lawrence F. O'Neill). (SW)

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FACILITIES MANAGEMENT

A Manual for Plant Administration

Rex O. Dillow, Technical Coordinator
Edited by Teresa Burnau Evans

The Association of
Physical Plant Administrators
of Universities and Colleges

Washington, D.C.

HE 017 916

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We thank George Weber who compiled the original *Basic Manual for Physical Plant Administration*. That manual served as the complete text for college and university plant administration for ten years and inspired this comprehensive manual.

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INTRODUCTION

Rex O. Dillow
Vice President for Professional Affairs
1981-1983

Postsecondary education has never been a unified system under effective centralized control. It is instead a composite of public and private institutions in 50 states and territories, each developing in response to unique requirements and varying types and degrees of organization and control. Yet the major forces affecting postsecondary education in the past 30 years have required sweeping and national adaptations. These influences have demanded solutions more universal than at any time in the past. These forces for change have contributed to the growth and development of professionals who manage education facilities. The magnitude of the requirements and functions assigned to the profession have enhanced the value and stimulated the development of the Association of Physical Plant Administrators of Universities and Colleges.

Four factors have contributed most to the current state of education facilities: (1) expanding enrollments of the 1950s and 1960s required extensive additions to physical plants, (2) increasing complexity of new facilities, (3) proliferation of government regulations pertaining to facilities, primarily regarding public safety and welfare, and (4) unprecedented increases in energy costs.

The GI Bill of Rights significantly increased the numbers of students attending college after World War II. This influx broke a stereotype—a college education was not just for the elite—and led to higher percentages of high school graduates continuing their education. Combined with the subsequent population growth, colleges and universities experienced an explosive growth in enrollment. The 1957 launching of Sputnik created a crisis of confidence in U.S. leadership in many academic fields, and brought about greater federal support of institutional research and teaching.

The growth in enrollment and increased emphasis on research created a demand for more facilities. Lawmakers responded with a largess beyond precedent. An "edifice complex" developed that linked growth with funding. Increasing enrollments served as the most persuasive arguments for additional funds. The plant value of all postsecondary education more than doubled in the 1950s: it increased almost fourfold in the 1960s.

In this period of adequate public funding and low operating and maintenance costs, little attention was given to operating efficiencies in the design of new buildings, or to timely maintenance and/or renovation of existing structures to modern standards of adequacy and suitability. Funds were devoted to meeting the most demanding requirement at the time—the addition of maximum floor space to handle growing enrollments and added research. Rooftop heating and cooling units, then inefficient in energy use and exposed to the worst possible maintenance conditions, were used in order to increase usable interior space. Mechanical systems were designed to furnish high ventilation rates and close year-round temperature control. Buildings contained vast expanses of glass and had flat roofs with little insulation. Lighting standards were scaled upwards, beyond what were subsequently determined to be optimum levels. Energy consumption in buildings constructed in the 1950s and 1960s ran 400 percent to 500 percent higher than that of pre-World War II buildings.

The 1970s produced a series of federal and state mandates establishing stringent building codes and standards. In 1977 the Department of Health, Education and Welfare published regulations for implementing Section 504 of the Rehabilitation Act of 1973, requiring program accessibility for handicapped students. Other governmental regulations pertaining to facilities management and operation were enacted. Most of them were concerned with health and safety, including environmental protection. All added funding requirements, not only for new structures, but also for bringing the vast existing plants into compliance.

The energy crisis arrived suddenly in 1973, precipitated by developments in international relations. Long neglected because of its ready availability and low cost, energy suddenly became a major factor requiring careful management. The large increases in cost, and shortages or threatened shortages of certain fuels, dictated changes in operating procedures and building alterations for improved energy efficiency. Universities had typically provided their own heating and cooling while purchasing electric power, potable water, sewage treatment, and solid waste disposal services from sources in the community. Economic advantages developed for integrating utility systems independently or in conjunction with the community, such as onsite electric power generation with use of residual heat for space heating and cooling, incineration of solid waste for its heat content, and partial re-use of effluent from sewage treatment for equipment makeup water and irrigation.

The late 1970s ushered in two new developments: an end to the period of sustained growth, and a faltering of traditional revenue sources. The force for expansion ceased to dominate at about the same time as the comfortable conditions promoted by the growth environment ended. Postsecondary education came under the same stresses that were acting on the rest of society—rising costs and dwindling resources. With declining enrollments and the competing claims of cities, public highways, the elderly, and environmental problems, education received a reduced share of the tax dollar.

In order to maintain quality education with diminished real dollar resources, college and university governance began to try to reduce administrative expenses in order to increase funds available for instruction, research, and academic support. Plant departments, the largest single unit in the managerial, administrative services area, often received the largest percentage of fund reductions. Many plant administrators came to realize that they were confronted with a new set of problems, problems for which they had developed no criteria for determining or justifying needed funds. This gave immediate rise to an admixture of crash methods such as average cost-per-square-foot, square-feet-per-employee, formula budgeting, etc.—all valuable comparative data but hardly adequate justification in support of fund requests.

Education is in transition, facing administrative problems that can only be solved by professionals. No requirement looms greater than that of providing a suitable physical environment for the teaching and research of postsecondary institutions. As we look forward, facilities administration in the rest of the 1980s may be characterized by five features:

Fund reductions. Rising costs, further reductions in the percentage of tax dollars assigned to education, and priority consideration to maintaining high quality in the primary institutional functions of teaching, research, and public service will further erode facilities funding.

Emphasis on existing facilities. Shift from new construction to existing facilities—preservation, renovation to modern standards of quality, alterations to meet changed program requirements, and space management including removing excess facilities from use to improve operation and maintenance efficiencies.

Professionalism in budgeting and administration. Professional programs and systems must be used for the operation, maintenance, and management of facilities. Funding requirements for the various functions must be determined and supported by factual information. Those requirements must be articulated clearly to funding authorities.

Close integration of academic, fiscal, and facilities planning. Institutional requirements cannot be met by simply dividing funds between academic and facilities needs. All facilities fund requirements relate directly to the effectiveness of the facilities in supporting the institution's teaching and research missions. A planning climate and system must exist to evaluate all fund requirements in light of that mission, and to maintain the unity of final decisions.

Greater emphasis upon leadership. Governmental mandates on collective bargaining, working conditions, health and safety, affirmative action, and equal opportunity have made personnel administration more complex and difficult. At the same time the need for greater productivity has made effective management of human resources most important. The requirement for technical competence has not lessened, but new administrative responsibilities and obligations have been added.

In the stable environment of education before World War II, physical plant functions emphasized trades methods and responded to customer requests. There was no commonly accepted definition of the responsibilities of a plant administrator, nor was it even considered a distinctive profession. Recent developments in education levied vast new requirements on facilities administration. The future will surely bring requirements even more difficult and perplexing. A common, though by no means universal, response to the changing demands has been to assign the new responsibilities to the plant department and to upgrade the capabilities of the department. Sometimes, however, the physical plant department has been splintered into separate specialist roles. Construction departments were created with central roles in new construction and other facilities projects, but without defining those roles relative to the maintenance and operation functions. Safety offices have been created outside the physical plant, with ill-defined roles for compliance with codes and standards. Other offices such as facilities management and energy management have been created. Lack of coordination has humorous, if not tragic, results. New buildings were constructed with incandescent lighting that physical plant replaced with flourescent, for greater energy efficiency, immediately upon occupancy.

The situation in postsecondary education points toward centralization of all facilities management functions under one chief administrator. This central administration will result in more economical operations, more efficient and comprehensive facilities planning, and better integration of facilities planning with academic and fiscal planning. A facilities administrator on a par with other top administrators can help plan for the most effective utilization of physical resources and for the most economical use of facilities funds in support of the institution's mission. This comprehensive facilities administration could not have been met by physical plants of the past, using antiquated methods and ideas, but we are entering a new age of expanded capabilities. In its present state, automation can contribute to more effective control of operations, as well as provide accurate and timely information for decision making.

The industrial sector is aware of the unique requirements of education institutions and will respond with improved technologies and processes for managing energy, utilities, and maintenance. The profession is attracting well-educated young people experienced in the latest technologies. The physical plant can now hire personnel with outstanding professional qualifications and can purchase the most sophisticated management assistance equipment.

An objective of plant professionals for the immediate future should be to identify and describe the functions and responsibilities that should be assigned to the physical plant department in order to achieve effective facilities management. As a corollary we need to describe the professional qualifications required to implement those functions and responsibilities. Our professional association, APPA, can then develop and administer programs addressing these defined responsibilities. APPA will advise and encourage the proper physical plant role in its liaison with other educational associations and with individual institutions.

This publication is an effort to provide comprehensive coverage of the major aspects of the plant profession today. Organized and outlined by the Professional Affairs Committee and the APPA staff in 1981, it is a work prepared by members for members and others associated with plant administration. It presents basic principles and considerations that will help individuals meet the requirements unique to their situation. Descriptions of successful systems or methods are intended as examples, not as recommendations.

Facilities Management is organized into five parts. Parts I: Personnel Services and II: Budgeting and Accounting cover support functions. The remaining three parts—III: Maintenance Management, IV: Plant Operations, and V: Planning, Design, and Construction—address the mainstream of physical plant functions. The conclusion describes proven methods and criteria for self-evaluation of the physical plant. This book should be viewed as a continuing project. New developments in the profession will necessitate changes. As it is used by members, requirements for additional information will become apparent; however, it is intended as a basic, long-lasting document. Elaborations on elements of the contents, tentative new methods, special problems requiring timely emphasis, and other short-term matters can best be handled by supplementary publications.

Facilities Management: A Manual for Plant Administration represents the best collective knowledge and efforts of the membership today. It is recommended to all members with confidence by the Professional Affairs Committee, the APPA officers, and staff.

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PERSONNEL SERVICES

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INTRODUCTION

The Plant Administrator's Work

George Berry
Director of Physical Plant
Medical College of Wisconsin

The maintenance and operation of mechanical equipment is rather straightforward. The machines require that their components be organized in definite ways, that they be fed a diet of oil, grease, belts and filters, and sometimes cooling water. They have none of the human traits of hate, jealousy, humor, curiosity; they do not require sick leave. They never, never become pregnant.

They do not organize into unions and never go on strikes. Machines do not require coffee breaks, vacations, do not file grievances. and are not insubordinate. Grounds, buildings, roofs, and utility systems have definable and predictable requirements similar to machines.

However, the most exasperating and most satisfying elements of physical plant work are the people and their relationships. There are no easy formulas, no maintenance or operational manuals, no as-built drawings that can help define these people relationships.

Volumes have been written on management, leadership, organizations, and almost every phase of people relationships. None of these books, even with time enough to read them all, will provide all the answers to personnel problems. These chapters on personnel management will in no way attempt to do what all those volumes cannot do. It will provide a modicum of practical information on some of the major areas of personnel management: organization, staff relations, salary administration, recruiting, training, and legal considerations.

One of the strengths of the Association of Physical Plant Administrators is the willingness of members to help one another. There is probably no problem that anyone might experience that has not occurred on other campuses. Therefore, if questions arise as you read this manual that are not answered, call or write the APPA office and/or another plant administrator. Help is always near.

CHAPTER 1

Organizational Relationships

Roger Allen
Director of Plant Operations
Central Michigan University

1.1 PURPOSE OF ORGANIZATION

The physical plant organization should provide a systematic approach to fulfilling the mission of the institution, and the objectives of the physical plant should be concomitant with the institution's. There are five outstanding results of a good organization:

- No duplication of effort.
- Defined lines of communication.
- Established lines of decision-making authority.
- Defined relationships between various functions of physical plant and other campus service areas.
- Clear, logical, and definite allocation of responsibilities with corresponding authority.

Good organizational relationships will avoid management by crisis. Facilities managers who spend most of their time putting out fires and reacting to emergencies will gain recognition as doers and problem solvers. However, the lack of planning and prior scheduling means lost production time as employees rush from one job to another. The end result is usually a high backlog of work and frustrated workers, supervisors, and clients—those groups the plant department serves.

1.2 PRINCIPLES OF EFFECTIVE ORGANIZATION

In any physical plant organization a structure must exist for smooth transfer of authority from top to bottom. When planning an organization use a systematic approach to analyzing the needs of the organization. First determine the objectives of the department. Then organize personnel to fulfill those objectives. Once the structure is in place, clear, concise policies and procedures must be established so all managers are aware of their respective responsibilities. Each level of management should then participate in developing goals and objectives, along with policies and procedures, for their respective areas within the guidelines of the department.

Distribution of Responsibility and Authority

With clearly stated policies and procedures in place at all levels of management, each level must exercise full responsibility for carrying out the objectives of their areas. This can only be accomplished when responsibility and equal authority are assigned to the individual managers. With rare exception, no manager can effectively answer to more than one supervisor. Good communications are a vital part of an efficient organization, and great care should be taken to assure a reasonable balance between the written and verbal word. Each level of management must be well-informed of the duties of the next lower level or their immediate supervisor. Then, in the manager's absence, a subordinate is able to assume the manager's duties. Often these duties may be divided between the immediate supervisor and the immediate subordinate.

Leadership Styles

Leadership styles vary and help determine the effectiveness of subordinates. There are many styles of leadership; most fit somewhere between autocratic (boss decides and announces decisions, rules orientation) and democratic (group is in charge of decisions, boss is coordinator, group makes rules). Whatever style one chooses on the spectrum, the leader role does not change. An important test of a good manager is consistency, regardless of leadership style.

Leadership is a relationship between people in which influence and power are unevenly distributed on a legitimate basis. Freud describes leaders as father figures, as people to whom group members transfer the feelings they have towards their fathers. These feelings include love, respect, and fear. No matter what the leadership style is, there are common ingredients in all styles of successful leadership that are discussed in Chapter 6.

1.3 PREREQUISITES FOR PLANT ADMINISTRATION

The key to successful facilities management is not the organizational structure itself, but rather a combination of the structure and the people who staff it. The principal plant administrator, by the nature of the work, must be a generalist. To be successful, each level of administration, up to and including the director, must become more general at each progression in administrative rank.

Education and Experience

The person most responsible for the success of a physical plant operation is the principal administrator (whose title varies from institution to institution). Two common titles are Assistant Vice President for Facilities and Director of Physical Plant (or Facilities). Since this position employs and supervises many people working in many professional and support tasks, it carries the responsibility and status comparable to an academic dean. In small institutions the plant administrator may have secondary duties for tasks such as stores, purchasing, student housing, and teaching. Facilities administrators have two primary roles:

- To serve as a resource for the institution by making accessible the talents and data of the department.
- To translate the institution's goals into action by organizing programs to achieve those goals.

Given the varied nature of the work, it is difficult to identify absolute prerequisites for the position. An APPA survey showed that preparation in engineering and business appears frequently in the educational background of successful plant directors. Capable directors also have come from related fields such as architecture, landscape architecture, and mathematics. Perhaps as important as formal training is broad, applicable experience in the field.

Personality Traits

Equally pertinent is character. The ideal personality profile for a physical plant director includes the ability to communicate effectively, to organize problem-solving responses quickly, and to recognize limitations. Plant directors must constantly communicate with diverse groups such as theoretical chemists, students, administrators, architects, supervisors, secretaries, contractors, and tradesmen. If a director cannot translate these groups' concerns into understandable programs, then he or she cannot do the director's job.

Responding to problems requires organizational aptitude, the ability to divide a task into its essential segments, and delegation of responsibility to capable personnel. Essential to delegating work is the ability to recognize personal and departmental limitations. The director is a manager of people, one who works by conceptualizing assignments and finding capable people to accomplish them. Unwittingly responding to problems beyond the scope of available talent indicates poor judgment and usually results in financial disaster.

1.4 ORGANIZATIONAL STRUCTURES

This discussion defines six major categories for the organization of a physical plant. There are probably no two physical plant organizations that precisely duplicate one another. Variations occur because of size, skills of individual people, and the idiosyncrasies of the institution. The functions listed below are not all-inclusive, but are general enough in nature to include most functions of a physical plant.

Administration

In addition to a director, there may be assistant administrators responsible for sub-departments within the division. Office staff will be responsible for such functions as accounting, personnel records, work order control, materials procurement, billing, and typical secretarial duties.

The director may also administer architectural engineering services, which plan, schedule, and draft documents and plans for alteration projects, and may supervise such projects whether they are contracted or completed with in-house staff.

Building and Equipment Maintenance

This functional category includes all items of routine repair of the building structure. It also includes regular and breakdown maintenance of building air, electrical, and plumbing systems within the structures. Employees with skills in carpentry, heating, ventilation, painting, glazing, locks and other hardware, roofing, sheet metal, furniture repair, and the maintenance of the utility distribution systems are required. Larger institutions may have specialists in these areas, but smaller institutions use generalists who can do many overlapping tasks.

Building maintenance crews may also provide services to auxiliary enterprises, alterations and improvements to academic departments, new construction, and repair to equipment on the inventory of other departments on a reimbursable basis. Charging other departments for services must be clearly defined and supported by the institutional administration. All concerned must understand what work the plant budget covers and what other departments will be expected to pay for.

Custodial Services

Custodial services include cleaning and maintaining coatings on soft tile, ceramic, concrete, and other floor surfaces; vacuuming and cleaning carpets; dusting and window cleaning; light bulb and tube replacement; and trash removal. Some custodial personnel may also be assigned to complete set-ups for special events, snow removal at building entrances, minor preventive maintenance on plugged drains, and opening and closing building entrances and windows.

Generally, cleaning laboratory bench tops, decontaminating radioactive facilities, and cleaning delicate instruments are the responsibility of the department having specific jurisdiction. For example, the biology department may contract cleaning services for fume hoods.

Utilities

The utility section of the plant department operates and maintains the central heating and air conditioning plant(s) and disposal facilities. Some campuses also have plumbers, steamfitters, and electricians who maintain the distribution system for gas, electricity, steam, chilled water, domestic water, high-temperature water, sanitary and storm drains. This may include the utility systems within the buildings, as well as the distribution systems throughout the campus.

Landscaping and Grounds Maintenance

Staffing for landscaping and grounds maintenance covers a wider spectrum of background and training than other facilities areas. At one end of the spectrum may be a landscape architect and at the other end a part-time high school student who shovels snow or mows lawns. Between these two extremes are employees with skills and knowledge to cultivate and maintain grass, trees, and shrubs. This group may also double as the snow removal crew in the winter.

Other tasks frequently assigned to the grounds crew include maintenance of structures such as retaining walls, riprap, drainage ditches, bus shelters, and benches, as well as operation and maintenance of grounds equipment.

This area may also include laborers who assist in construction and remodeling, demolition and removal, or material delivery.

Major Repairs and Renovation

Again, the size of the campus may determine the size of this department. Major repairs, remodeling, and renovations must be performed on all campuses at some time. The planning, design, and administration of these functions and the typical building trade skills may be done by in-house staff or by contractors.

Some institutions hire their own architects and engineers to plan, design, and administer major repair or renovation projects. Others may choose to have outsiders on retainers or to contract for these services job by job.

The building trades personnel are sometimes assigned to this function on a full-time basis, or they may shift back and forth from the building equipment and maintenance department. The problem with this latter arrangement is that the routine maintenance is postponed time and again to handle requests for alterations. This is especially true when remodeling and renovation are funded by departments other than physical plant. Good facilities management must continually strive to avoid deferring routine, but vitally important, maintenance functions.

Other Services

Physical plant departments are sometimes assigned other essential services of a campus. Among them are—

- Automotive repair.
- Bus systems.
- Construction planning and inspection.
- Communications (telephone and telegraph).
- Fire protection.
- Mail and messenger service.
- Property insurance.
- Purchasing and stores.
- Safety.
- Security.
- Solid waste disposal.
- Traffic.
- Trucking and moving.

1.5 STAFFING REQUIREMENTS

Organization efforts are fruitless without serious consideration being given to people, the work they must accomplish, the work environment, and communication. People, although competent and well trained, do not work in isolation. They must work together systematically to achieve the best results possible from their combined efforts with a minimum degree of confusion, conflict, and frustration. Well-defined duties and lines of authority are necessary to develop interdepartmental relationships. Thorough written job descriptions for each position are required to accomplish this end.

The plant department is comprised of both line administrators, who accomplish work through other people, and staff employees, who are not responsible for the work of other people but provide a support service to the department. Great care must always be exercised to ensure that staff administrators are not given authority *without* the corresponding responsibility. Everyone must contribute to a common game plan that uses employees' skills and knowledge in the productive and efficient operation of the facilities department. Many relationships occur within the specific functions to achieve the desired result—completion of the work and a satisfied customer. All in a timely and cost-effective manner.

Sometimes the goals of the institution cannot be met with the labor or material resources available to the physical plant. Fluctuating work loads of remodeling or major replacements projects are not uncommon in facilities management. Thus, it may be prudent to contract certain projects to outside contractors. Sometimes it is more economical to complete several small projects with the institution's existing labor force on an overtime basis. Consider this prior to contracting to an outside firm.

The decision to use contract services requires a great deal of teamwork. Communication channels must be maintained between the operation and maintenance function with the planning and construction function. A collective effort will result in achieving an efficient and smooth operation.

1.6 INTERDEPARTMENTAL RELATIONSHIPS

Equally important to the relationships within the department are the relationships with all other departments of the institution. There is no department or section thereof at any institution that does not, in some way, use the services of physical plant. Several departments of the institution, in turn, provide a direct service to the plant. Examples are personnel, purchasing, payroll, computer services, and stores.

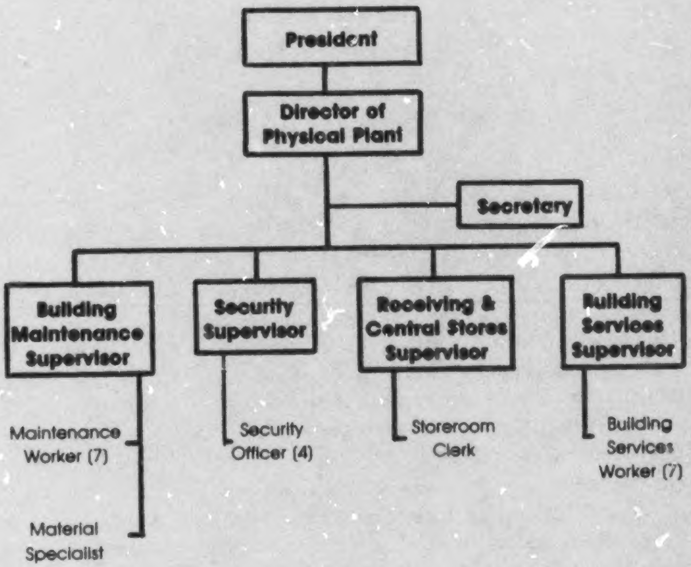
Open and honest communications between the various departments is a must for the success of any institution. Just as the plant department must provide economical and timely service to other departments, so must we expect the same from them. Just as plant managers must be cautious about dictating their needs to other departments, neither should the reverse occur.

Because the other service departments are specialized in their areas of responsibility, they are in a position to be more knowledgeable of good practices, rules, regulations, and standards. Use that expertise in making proper decisions for the department. Department communications should flow freely between the principal plant administrator and his or her designees and all other departments within the institution.

1.7 ORGANIZATIONAL CHARTS

The following samples of organizational charts are meant to show the reader a few of the many in existence, representing various-size institutions. Some represent campuses that house 50 percent or more of their students, while others are totally commuter campuses with no housing. A good organization and smooth operation are inseparable. A poor organization is one in which the parts are not properly laid out, where there may be duplication of effort, misunderstandings of responsibilities, poor coordination and supervision, and confused purpose with restricted achievement. A most vital point to remember when designing an organization is: an organization is an arrangement of the working relationships of individuals, not merely an impersonal process of putting blocks together.

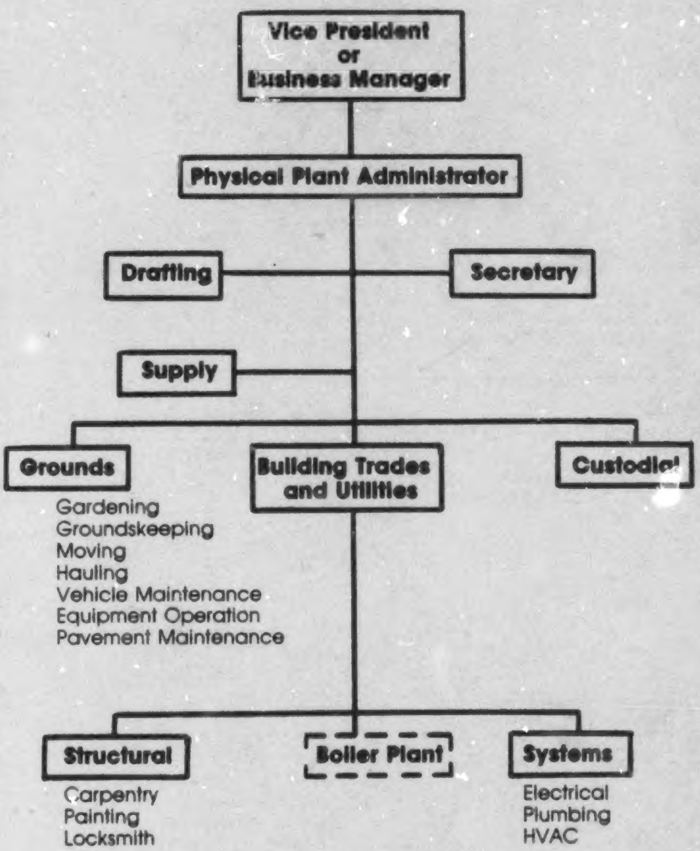
Figure 1-1


President
Director of Physical Plant
Secretary
Building Maintenance Supervisor
Security Supervisor
Receiving & Central Stores Supervisor
Building Services Supervisor
Maintenance Worker (7)
Material Specialist
Security Officer (4)
Storeroom Clerk
Building Services Worker (7)

- College of 240 full-time equivalent students.
- Commuter campus, no housing.
- 190,000 gross square fee.

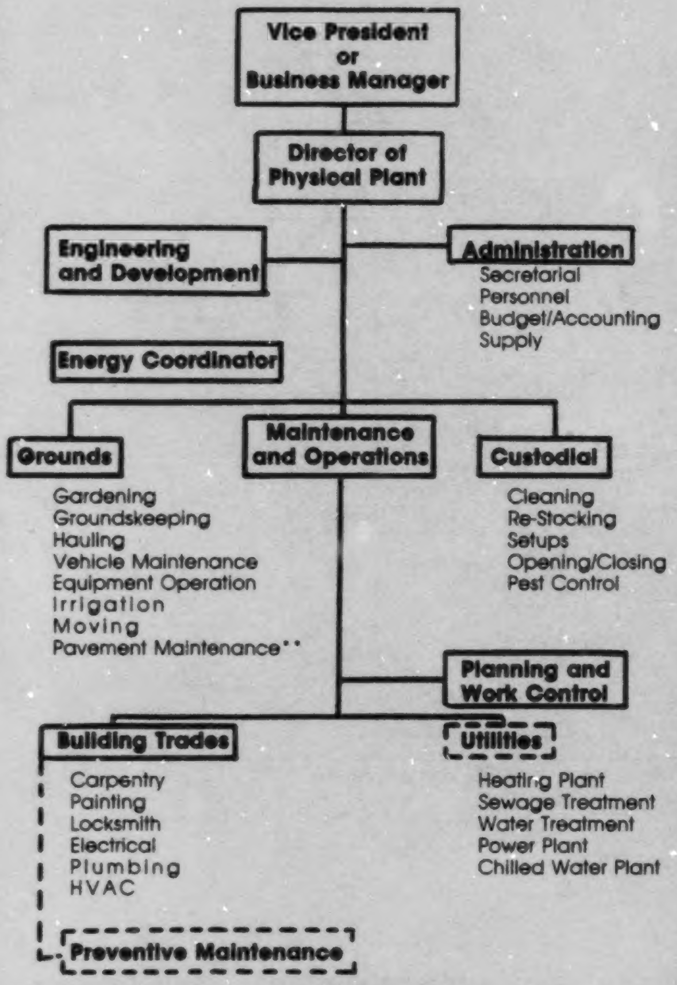
Figure 1-2

Typical Small Maintenance Organization*


Vice President
or
Business Manager
Physical Plant Administrator
Drafting
Secretary
Supply
Grounds
Gardening
Groundskeeping
Moving
Hauling
Vehicle Maintenance
Equipment Operation
Pavement Maintenance
Building Trades and Utilities
Custodial
Structural
Carpentry
Painting
Locksmith
Boiler Plant
Systems
Electrical
Plumbing
HVAC

*Up to 500,000 GSF, less than 80 employees.

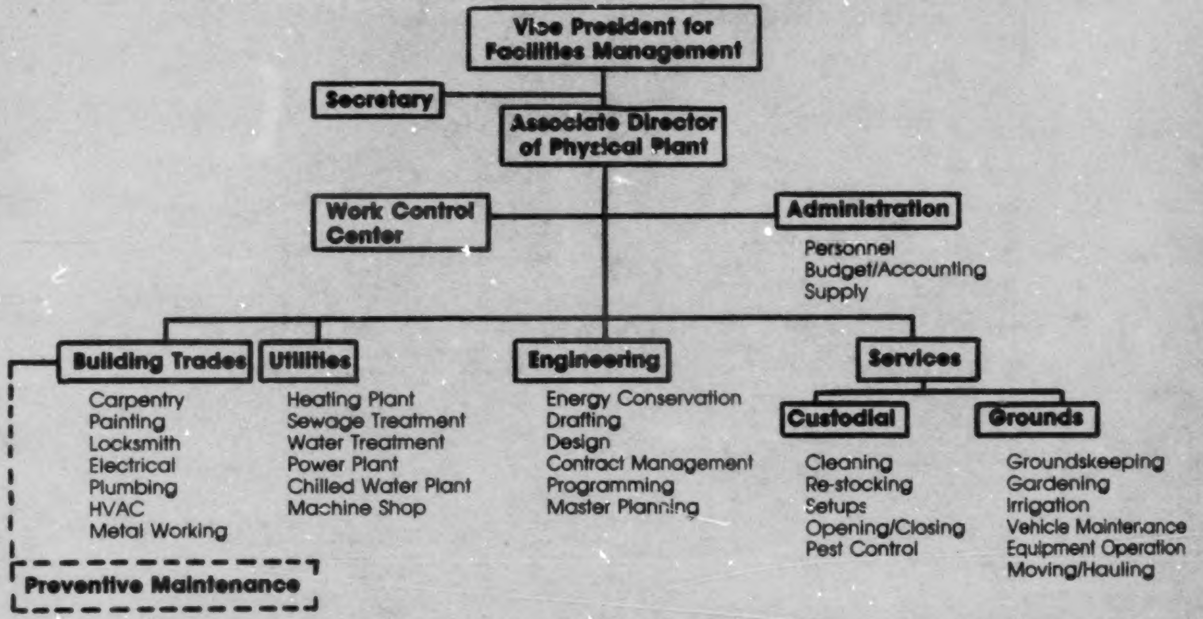
Figure 1-3
Typical Medium Sized Maintenance Organization*


Vice President or Business Manager
Director of Physical Plant
Engineering and Development
Administration
Secretarial
Personnel
Budget/Accounting
Supply
Energy Coordinator
Grounds
Gardening
Groundskeeping
Hauling
Vehicle Maintenance
Equipment Operation
Irrigation
Moving
Pavement Maintenance**
Maintenance and Operations
Custodial
Cleaning
Re-Stocking
Setups
Opening/Closing
Pest Control
Planning and Work Control
Building Trades
Carpentry
Painting
Locksmith
Electrical
Plumbing
HVAC
Utilities
Heating Plant
Sewage Treatment
Water Treatment
Power Plant
Chilled Water Plant
Preventive Maintenance

*500,000 GSF to 2 million GSF, 85 to 200 employees.

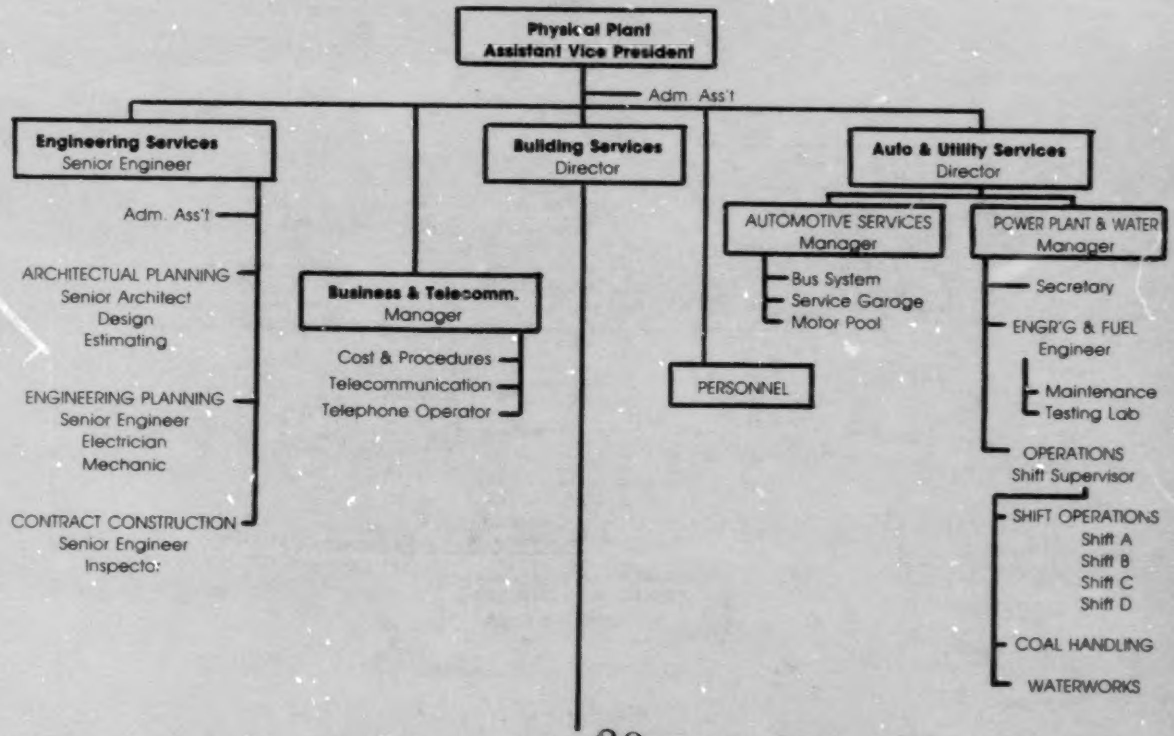
Figure 1-4

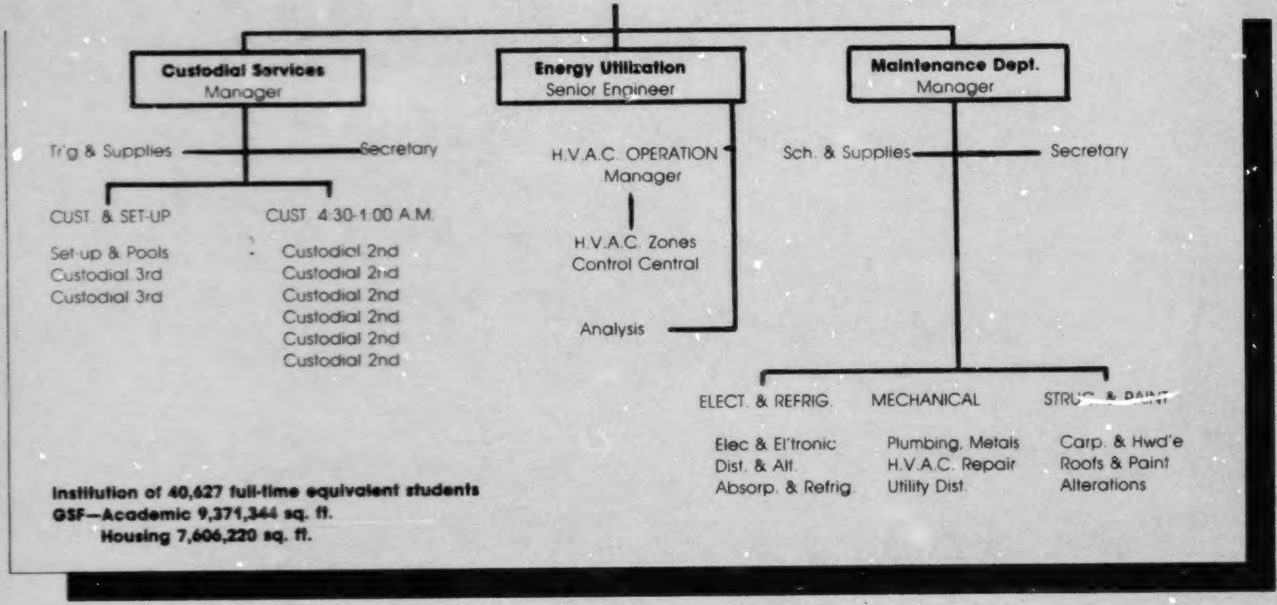
Typical Large Maintenance Organization*


Vice President for Facilities Management
Secretary
Associate Director of Physical Plant
Work Control Center
Administration
Personnel
Budget/Accounting
Supply
Building Trades
Carpentry
Painting
Locksmith
Electrical
Plumbing
HVAC
Metal Working
Utilities
Heating Plant
Sewage Treatment
Water Treatment
Power Plant
Chilled Water Plant
Machine Shop
Engineering
Energy Conservation
Drafting
Design
Contract Management
Programming
Master Planning
Services
Custodial
Cleaning
Re-stocking
Setups
Opening/Closing
Pest Control
Grounds
Groundskeeping
Gardening
Irrigation
Vehicle Maintenance
Equipment Operation
Moving/Hauling
Preventive Maintenance

*More than 2 million GSF and 200 employees.

Figure 1-5


Physical Plant
Assistant Vice President
Adm. Ass't
Engineering Services
Senior Engineer
Adm. Ass't
ARCHITECTUAL PLANNING
Senior Architect
Design
Estimating
ENGINEERING PLANNING
Senior Engineer
Electrician
Mechanic
CONTRACT CONSTRUCTION
Senior Engineer
Inspecto:
Business & Telecomm.
Manager
Cost & Procedures
Telecommunication
Telephone Operator
Building Services
Director
PERSONNEL
Auto & Utility Services
Director
AUTOMOTIVE SERVICES
Manager
Bus System
Service Garage
Motor Pool
POWER PLANT & WATER
Manager
Secretary
ENGR'G & FUEL
Engineer
Maintenance
Testing Lab
OPERATIONS
Shift Supervisor
SHIFT OPERATIONS
Shift A
Shift B
Shift C
Shift D
COAL HANDLING
WATERWORKS


Custodial Services
Manager
Tr'g & Supplies
Secretary
CUST. & SET-UP
CUST. 4:30-1:00 A.M.
Set-up & Pools
Custodial 3rd
Custodial 3rd
Custodial 2nd
Custodial 2nd
Custodial 2nd
Custodial 2nd
Custodial 2nd
Custodial 2nd
Energy Utilization
Senior Engineer
H.V.A.C. OPERATION
Manager
H.V.A.C. Zones
Control Central
Analysis
Maintenance Dept.
Manager
Sch. & Supplies
Secretary
ELECT. & REFRIG.
MECHANICAL
STRUC. & PAINT
Elec & El'tronic
Dist. & Alt.
Absorp. & Refrig.
Plumbing, Metals
H.V.A.C. Repair
Utility Dist.
Carp. & Hwd'e
Roofs & Paint
Alterations

Institution of 40,627 full-time equivalent students
GSF—Academic 9,371,344 sq. ft.
Housing 7,606,220 sq. ft.

CHAPTER 2

Recruitment and Employment Practices

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2.1 RECRUITMENT AND EMPLOYMENT

People are the most important asset of an organization. The recruitment process either opens or slams the door to people, and for this reason it is essential that recruitment be done on a systematic and well-informed basis.

Recruitment may be viewed as the attempt to match the needs of the organization with the skills and aspirations of the individual applicant in an optimal way. People do their best work when they have a strong expectation of being well-adjusted to their work and their environment.

Job Descriptions

To begin the process of recruitment, first analyze the job to be filled. A job is a collection of tasks that compose the work of one person. A task is a major element of work intended to achieve a specific result. A job may be analyzed most effectively with a written job description that includes the following elements:

- The purpose of the job.
- The positions within the organization.
- Principal duties and responsibilities.
- Specific tasks.
- Working relationships.

The job description provides the basis for identifying those qualifications a person needs to do the job. Qualifications must be realistic. Over- or under-qualified people have a low success rate. Qualifications should be stated in specific terms: that is, level of education, prior work experience, specialized skills, level of intelligence, and essential personality characteristics.

Candidate Search

After determining specific qualifications, the next step is attracting a field of applicants. It is wiser to try to attract a large number of applicants and narrow the field through an initial screening process than to attract only a small number of qualified applicants. Never compromise selection standards. An underqualified applicant will only make him- or herself unhappy, as well as the organization. Common recruitment sources are listed below:

- Recommendations and referrals.
- Newspaper advertising.
- Advertising in trade, professional, or business journals.
- Private employment agencies.
- Public employment agencies.
- High-school, trade, and technical services.
- Professional sales and business organizations.
- Recruiting at conventions and professional society meetings.
- College recruitment.
- Executive search firms.
- Unsolicited applicants.
- Minority and women career centers.

Screening Process

Many managers spend too much time interviewing unqualified applicants. Some people may be screened out based on their application and/or resume. Some may be screened out by a short initial screening interview that determines whether the applicant has the necessary qualifications and tactfully eliminates unqualified applicants.

Title VII of the Civil Rights Act of 1964 specifically permits, even encourages, companies to use professionally developed psychological selection techniques, including testing. The Tower amendment states, "... nor shall it be an unlawful employment practice for an employer to give and to act upon the results of any professionally developed ability test." Many companies have given up testing rather than try to comply. An employment test must be professionally developed and validated and be based on ability that is needed for the job. It must not discriminate, nor may it continue the results of past discrimination.

Most companies no longer check employment references because of EEO problems. There are three methods of checking references—by mail, in person, and by telephone. The most effective is the use of a structured and sequential questionnaire asked over the telephone.

For EEO purposes, there are certain facts about each applicant that must be recorded and kept for one year. These are—

- Date of application.
- Name of applicant.
- Minority group, if any.
- Sex.
- Position applied for.
- Appropriate EEO classification category.
- Disposition of application.
- Specific recruiting source that referred applicant.

One of the best ways to predict an applicant's future job performance is to take a look at what the applicant did in the past.

Interviewing Techniques

For better results in conducting job interviews, follow these guidelines. Establish rapport with the applicant. Have a plan of questions and what to discuss. Do not make the interview too short. Be aware of your own biases. Do not talk too much. Do not rely on intuition. Do not overemphasize the first impression.

The job interview may be broken into six separate parts:

1. Introducing yourselves and welcoming the applicant.
2. Engaging in some small talk.
3. Obtaining relevant interview information.
4. Providing the applicant with information about the company and the job.
5. Responding to the applicant's questions.
6. Concluding the interview.

After conducting the job interviews, the final step is to rate each applicant on each selection standard. This provides an objective view of each applicant and helps to ensure that the best person for that particular job is selected.

2.2 PROMOTION POLICIES

There are three essential ingredients to successful promotion of staff—the establishment of career ladders, the announcement and posting of all promotional opportunities, and the thoughtful choice of selection criteria. Also affecting promotion policies may be local civil service regulations, union-negotiated agreements, affirmative action plans and goals, local school policies, and settlements of grievances.

Promotions for staff should be done objectively, fairly, and openly. Staff should be acquainted with promotion policies and individual requirements. Objectivity in selecting people for promotion helps to ensure that the most qualified people are promoted.

Career Ladders

This refers to the relationship among certain jobs. Experience gained in one of the lower jobs on the career ladder will qualify a person for consideration for one of the next higher jobs on the career ladder. This enables an individual to come into the organization at an entry-level position and, through time and experience, progress through various related jobs. It is possible for an individual to join a physical plant as a crafts helper, and through experience on the job and good ratings as an employee, go from helper to craftsman, to senior craftsman, to foreman, to superintendent, and perhaps to engineer, or even director.

Job Announcements and Postings

All promotional opportunities should be announced and posted where all personnel may see them. Announcements should explain how interested people may apply, and the selection criteria must also be included in announcements. Job announcements are generally posted for seven to ten days, but local policies must be established to determine the specific length of time. Procedures for filling positions in an emergency must also be developed.

Selection Criteria

The selection criteria outline the qualifications a person must have in order to perform the job well and are derived from the written job description. For example, the job description of the director's secretary might read—

> Provides rapid typing support and types accurately. Takes dictation and minutes of meetings. Maintains director's files.

The selection criteria might read—

1. Able to type 60–75 words per minute with 2 percent or less error rate.
2. Able to take shorthand or speedwriting at 120 words per minute with 2 percent or less error rate.
3. Knowledge of filing systems, and able to file 50 documents per week with no errors.

From this description of specific job duties, the candidates' qualifications are compared. The recruiter can make a quantitative decision based on these qualifications.

There are several objective methods of rating applicants. A weight may be assigned to each criterion. Then each person is given a rating in terms of how well he or she meets each criterion. Another method is to evaluate each individual's percentage of meeting 100 percent of each criterion, assuming that each criterion is of equal value.

These selection criteria also may be used as standards for a person's annual performance review. If used as such, individuals must be told when hired that these are the expectations and that their annual performance review will reflect how well they met those expectations.

2.3 EQUAL OPPORTUNITY LEGISLATION

There are four federal legal sources that prohibit discrimination in all aspects of employment— hiring, firing, promotions, and training of employees. Equal opportunity is guaranteed by the U.S. Constitution, federal laws, Executive Orders, and court interpretations and decisions.

U.S. Constitution

The Fifth Amendment (1791) prohibits the federal government from engaging in discriminatory actions or policies and ensures that "no person shall ... be deprived of life, liberty, or property, without due process of law." The Fourteenth Amendment (1868) applies the provisions of the Fifth Amendment to state and local governments.

Federal Laws

During the 1960s and early 1970s, there was an explosion of federal legislation dealing with all areas of employment discrimination. Before 1963, there were only two statutes concerning employment discrimination. Following are all the current federal laws with which employers must comply.

- The Civil Rights Act of 1866 (Section 1981 U.S. Code, Title 42) was enacted to enforce the Thirteenth Amendment prohibiting slavery. This law specifically mentions the right to contract and later was interpreted to mean the right to contract for employment.
- The Civil Rights Act of 1871 (Section 1983 U.S. Code, Title 42) was enacted to enforce the Fourteenth Amendment. State and local governments cannot deprive any person of any rights secured by the Constitution and laws. Violators are liable for prosecution by the injured party.
- The Equal Pay Act of 1963 prohibits wage discrimination based on sex. It applies to both the public and private sectors and is

administered by the Department of Labor. It was enacted as an amendment to the Fair Labor Standards Act of 1938.

- Title VI of the Civil Rights Act of 1964 prohibits employment discrimination in federally assisted programs, as well as prohibiting discrimination against the beneficiaries of federal assistance programs.
- Title VII of the Civil Rights Act of 1964 as amended by the Equal Employment Opportunity Act of 1972 prohibits all forms of employment discrimination on the basis of race, color, religion, sex, or national origin. It covers both public and private employers, employment agencies, labor unions, and joint labor-management apprenticeship committees. It also bans discrimination against someone because she or he files a Title VII complaint. The law is administered by the Equal Employment Opportunity Commission (EEOC).
- The Age Discrimination in Employment Act of 1967 prohibits employment discrimination based on age. It applies to public and private employers, employment agencies, and labor unions. The protected class is employees between the ages of 40 and 64. It is administered by the Department of Labor.
- The Civil Rights Act of 1968 (Title I—Interference with Federally Protected Activities) provides criminal penalties for interference with an individual's employment rights because of race, color, religion, or national origin.
- The Intergovernmental Personnel Act of 1970 provides for intergovernmental cooperation in the administration of grant-in-aid programs, grants for improvements in state and local personnel administration, federal assistance in training employees, and federal grants for training. To qualify for technical and financial assistance the employer must comply with certain merit principles such as fair treatment.
- The Public Health Service Act of 1943, as amended in 1971, prohibits funding to any medical school or health-training facility unless the Department of Health receives satisfactory assurance that the school is not, or will not, discriminate on the basis of sex in employment or admission of individuals to training programs.
- Vietnam Era Veterans Act of 1972 requires special emphasis be given to the employment of qualified disabled veterans or veterans of the Vietnam Era by those employers receiving federal funding or under federal contract. It is administered by the Department of Labor.

- Title IX of the Education Amendments of 1972 prohibits sex discrimination in employment, admissions, and treatment of students in all federally funded education programs.
- The State and Local Fiscal Assistance Act of 1972, commonly known as the General Revenue Sharing Act, prohibits discrimination in any program or activity funded in whole or in part with revenue sharing funds. It is administered by the U.S. Treasury Department.
- Section 503 of the Rehabilitation Act of 1973 provides that any contractor or subcontractor (over $2,500) shall take affirmative action to employ and advance in employment qualified handicapped individuals.
- Section 504 of the Rehabilitation Act of 1973 prohibits discrimination based on handicap by providing that any recipient, public or private, of HEW (now HHS and ED) funds must take positive steps to employ and promote qualified handicapped persons through reasonable accommodations and services. Programs and activities of the funded organization must be made accessible to the handicapped. Executive Order 11914 extends this section to all federal agencies granting assistance.

Executive Orders

Executive Orders are directives issued by the President to clarify, extend, or explain existing federal legislation. There are three Executive Orders that relate directly to equal employment opportunity.

- Executive Order 11141, issued by President Lyndon B. Johnson on February 3, 1964, prohibits federal contractors and subcontractors from discriminating based on age "except upon the basis of a bona fide occupational qualification, retirement plan, or statutory requirement."
- Executive Order 11246 as amended by 11375, signed by President Lyndon B. Johnson on September 24, 1965, prohibits discrimination by nonexempt government contractors and subcontractors on the grounds of race, color, religion, sex, or national origin. It applies to hiring, upgrading and promotion, apprenticeship programs, testing procedures, wage and fringe benefits, cosponsored training programs, education, tuition assistance, transfers, layoffs and seniority practices, and other related conditions of employment. This order also established the Office of Federal Contract Compliance (OFCC) within the Department of Labor to administer and enforce the order.

- Executive Order 11478, signed by President Richard M. Nixon on August 8, 1969, prohibits discriminatory practices in federal government employment on the basis of race, color, religion, sex, or national origin.

The courts have interpreted these laws to mean that all groups in the labor force are entitled to equal employment opportunity throughout all levels and subdivisions of the organization, unless business necessity precludes such consideration. The burden of proof rests clearly upon the employer to justify any exception to the general rule of nondiscrimination.

Griggs v. Duke Power Company (401 U. S. 424-1971) held that the results and the consequences of an employer's actions must be considered rather than its intent *not* to discriminate. If an employer's action has a "disparate effect" (an uneven or numerically disproportionate impact) on members of a protected class, or perpetuates the effect of previous discriminatory practices, then such action shall constitute unlawful discrimination unless the employer can prove business necessity.

Further, the courts have held that where barriers to equal employment opportunity exist, positive and affirmative action is required by all organizations, regardless of whether or not they hold a government contract.

2.4 AFFIRMATIVE ACTION

Affirmative Action is a set of written, specified, and result-oriented procedures designed to achieve equal employment opportunity within an organization. To develop an acceptable affirmative action plan the employer must first analyze its employment of minority groups and women, and determine where it is deficient. Next, the employer must develop goals and timetables to which good-faith efforts may be directed to correct the deficiencies and increase the use of minorities and women at all levels of the work force where deficiencies exist.

Affirmative Action Plan

There are eight steps that should be followed to develop a written affirmative action plan.

1. Top management must write a policy statement in support of affirmative action and its intent to follow such a plan.
2. Top management must appoint an official to direct and implement the program.
3. The employer must publicize the program both internally and externally. One common method of publicity is to include a statement about being an equal opportunity employer on the organization's stationery.

4. The employer must analyze its employment of minorities and women by department and job classification.
5. The company must then develop specific affirmative action goals and timetables for reaching those goals.
6. The employer must develop and implement the program.
7. The appointed official must develop internal audit and reporting systems to evaluate the effectiveness of the program.
8. The company also must organize appropriate additional supportive training and development programs. Affirmative action plans do not work unless first-line supervisors understand their responsibilities.

2.5 PAYROLL PRACTICES

Some plant employees work at unusual hours and occasionally accumulate considerable overtime. Custodians, plant engineers, and security police often work night shifts. Maintenance men, moving crews, and groundskeepers work overtime for several weeks at the beginning and end of each academic period. As a standard procedure, the interviewer should warn applicants for these positions that such conditions are part of the job, and that supervisors accept no excuses for not complying with overtime requirements.

Pay Differentials

The director can mitigate these disadvantages in several ways. All night work, for instance, should qualify for some night differential premium–either a flat hourly increase or percentage of the worker's normal rate. According to many state laws, work beyond eight hours a day requires additional pay. All work time beyond 40 hours per week must be paid at the overtime rate in institutions that receive any federal funds (i.e., grants, student loan funds, capital building funds, etc.).

Overtime

Overtime should be distributed as equally as possible among qualified employees. If an employee refuses overtime on one occasion, he or she should not be excluded from future opportunities.

For more traditional services such as maintenance and groundskeeping, it may be more efficient to have employees report earlier for work than students begin classes. This reduces traffic problems and provides time for emergency maintenance or special preparation for the day's classes. In drawing up work schedules, facilities managers should consult with supervisors and employees to determine the most appropriate work times. A simple change—like moving the reporting time 15 minutes to coincide with local bus schedules—may ease transportation problems and improve worker morale.

To maintain morale it is best for all employees to work essentially the same number of hours every day. Scheduling certain personnel, such as office workers, for a shorter work day can hurt staff morale. Once established shorter work weeks are seldom changed.

Standby

Another common scheduling problem is the standby roster. For some essential services, it is necessary to place skilled employees on call in case an emergency requires immediate repairs. While on standby status the workers must remain accessible when off duty, perhaps by telling a supervisor or dispatcher where to call at all times. One way to handle this problem is to list each employee, perhaps alphabetically, and require each to take a turn. The rotation need not be inflexible; individuals willing to trade can arrange switches among themselves. To justify the disruption of leisure, it is traditional and advisable to provide a small premium for remaining on standby alert. Institutions generally pay travel expenses and at least two hours of pay, or at least four hours of pay and no travel expenses to the employee who is called back.
(Also see Chapter 4, Wage and Salary Administration.)

2.6 RECORDKEEPING

It may be a duplication of effort for the physical plant office to maintain a set of employee records when those records are also maintained in the institution's personnel office. This redundancy provides two distinct benefits. First, employees can find whatever information they need in their home office, a benefit that helps develop a sense of departmental identity and loyalty. Second, the plant director who keeps complete records on hand retains management authority that otherwise might fall by default to another office. The following describes items kept in an employee's personnel jacket in the plant office.

Application Form

The basic document is the job application form. It provides information such as name, social security number, local address, birthdate, marital status, education, previous work experience, military service, job title, date of employment, and salary.

Photographs and Fingerprints

There are distinct advantages to having pictures and fingerprints in the personnel file. The photographs may create fears about racial discrimination. Fingerprints may be objectionable if a potential employee has a police record that has not been reported in the application. Fingerprinting, however, can discourage omissions and falsification of previous police records. It can also protect employees from unwarranted suspicion in the event of thefts. Many schools participate in rehabilitation programs by hiring people with previous police records. Few schools, however, tolerate deliberate concealment of such information.

Performance Memos

One of the most important uses of the employee file is as a repository for memos of commendation and criticism. The awareness that special efforts and deficient performance are recorded in writing can be an incentive to better work. Performance appraisals are discussed in detail below.

Payroll Card

A payroll card with a complete financial account of the individual's tenure at the institution is a service to the employee. The essential data on such a form are date of employment, original job title, starting salary, increases earned, reclassifications, and present salary. From such a card, the secretary or personnel clerk can quickly answer most questions an employee might ask.

Attendance Records

As a backup to payroll cards, the department should maintain complete attendance records. For tradesmen, laborers, and others on hourly wages, time cards are used. A clerk totals on a master time sheet. For supervisors, office personnel, and others on straight salaries, a daily attendance sheet notes any absences. These documents help resolve disputes about sick leave taken, amount of annual leave earned, and similar fringe benefits.

Many employers ask employees to request time off in writing in advance. If the time off is for unanticipated sick leave, the request form should be completed immediately after an employee returns. Copies of these requests help settle questions regarding leave balances if employees see their own signatures on past requests.

2.7 SEPARATION PAPERS

The final item in the employee's file is his or her separation papers. These papers include all information pertinent to accrued benefits, such as leave and retirement pay. To ensure that the separation proceeds smoothly, the director should compile a checklist of all required actions. The statement of cause of separation should specify whether the employee resigned to take another job, relocate, advance her or his career, or was fired. Such information is valuable both to employees, since they may want a reference letter from the institution, and to the institution. Planners can use this data in formulating future personnel policies. The statement of cause of separation may also provide insight to possible unemployment compensation claims and equal opportunity discrimination hearings.

2.8 PERFORMANCE APPRAISAL PROCESSES

Performance should be evaluated on each and every employee at least annually, using a form similar to the one shown (Figure 2-1) with the following guidelines:

Preparing for the Rating

1. Familiarize yourself with the contents of the evaluation form. Analyze its general scope as well as the general instructions.
2. Understand thoroughly the duties and requirements of the particular position held by the employee to be rated.
3. Use a process of objective reasoning—eliminating personal prejudice, bias, or favoritism. Don't allow your own personal likes or dislikes of certain mannerisms to influence the rating.
4. Don't assume that excellence in one factor implies excellence in all factors. Observe and analyze the employee's performance in each factor individually.
5. Base your judgment on demonstrated performance—not on anticipated performance. The evaluation is to be based on what has happened, not on what might happen.
6. Evaluate on the basis of the entire rating period. It is better not to consider only single accomplishments or failures, or the most recent performance. Achievements or failures should be considered in context with the total performance for the period.
7. Consider seniority apart from performance—an employee with a short service record may not necessarily be less effective than one with a longer term of employment.
8. Consider the requirements in terms of the level of the position—an individual in a lower classification may be meeting the requirements of his or her job more effectively that the immediate supervisor does in his or her position in a higher classification.

9. Space has been provided on the performance evaluation report forms for additional factors the evaluator considers important enough to be included in the overall appraisal of the employee.

The Evaluation Interview

1. Review your initial evaluation of the employee's performance and consider why you evaluated the work as you did.
2. Plan to meet in private. If this is the employee's first evaluation interview, anticipate tension, anxiety, or curiosity, and be prepared to minimize these.
3. Create the impression that you have time for the interview and that you consider it important.
4. Make the employee feel that the interview is a constructive, cooperative one by placing primary interest upon his or her development and growth.
5. Be open-minded to the opinions and facts presented by employees. Be willing to learn about them. Don't dominate or cross-examine. Avoid argument. Employees must do most of the talking sometime during point of the interview:
   - In bringing opinions and feelings to the surface and to your attention.
   - In gaining a better understanding of themselves.
   - In identifying their own areas of needed or potential improvement, and in making plans for accomplishing this.
6. Talk about the employee's strengths first, covering each point in some detail. This practice helps start the interview off on the right foot. While building upon the employee's strengths, *do not fail* to discuss weaknesses or failures and *how to prevent or curtail them* in the future. At this point introduce your suggestions for a specific improvement program.
7. The evaluation interview should end when you have made clear whatever points you intended to cover, when the employee has had a chance to review his or her problems and release any emotional tensions that may exist, when plans of action have been cooperatively developed, and when a natural stopping point has been reached. Reassure employees of your interest in their progress and indicate willingness to take up the discussion again at any time. It may be appropriate to schedule a follow-up meeting to monitor progress.

8. Secure the employee's signature, then date and sign the report. Forward it to the department head who will review and sign the report and forward it to the personnel department. The report is kept in the employee's personnel folder, available to both employee and supervisor. The report is not available to anyone else.

Figure 2-1

Staff Performance Evaluation

Employee's Name ______________________ **Evaluation Date** __________

Department ______________________ **Job Title & Code** ________

Evaluating Supervisor ________________ **Date of Employment** ____

Instructions: Supervisor should prepare form entirely before holding the conference with the employee. This is a time for positive comments first, followed by constructive criticism. A frank and cordial atmosphere should be fostered that should result in a helpful dialogue between supervisor and employee. At the end of the conference employee should take the form to study, write reactions, and sign. Upon request, a copy may be made for employee.

Rating Scale:
1 = Superior
2 = Commendable
3 = Satisfactory
4 = Marginal
5 = Unsatisfactory

Factors

Cooperation	1	2	3	4	5
1. In relationship with other employees	☐	☐	☐	☐	☐
2. In relationship with supervisor	☐	☐	☐	☐	☐
3. In relationship with the public	☐	☐	☐	☐	☐
4. In working toward departmental objectives	☐	☐	☐	☐	☐
Initiative					
1. Resourcefulness	☐	☐	☐	☐	☐
2. Fidelity to established procedures	☐	☐	☐	☐	☐
3. Creative	☐	☐	☐	☐	☐
4. Constructive thinker	☐	☐	☐	☐	☐
Productivity					
1. Speed of work	☐	☐	☐	☐	☐
2. Steady worker	☐	☐	☐	☐	☐
3. Task persistence	☐	☐	☐	☐	☐
4. Gets things done	☐	☐	☐	☐	☐
Quality					
1. Degree of errors	☐	☐	☐	☐	☐
2. Faithfulness to standards	☐	☐	☐	☐	☐
3. Appearance of finished work	☐	☐	☐	☐	☐
4. Supervision required to ensure quality	☐	☐	☐	☐	☐

Job Knowledge

1. Understanding of duties	☐	☐	☐	☐	☐
2. Ability to handle equipment used	☐	☐	☐	☐	☐
3. Versatility in varied tasks	☐	☐	☐	☐	☐
4. Capable of complex assignments	☐	☐	☐	☐	☐

Dependability

1. Gets to work on time	☐	☐	☐	☐	☐
2. Attendance record	☐	☐	☐	☐	☐
3. Can be trusted with money, valuable equipment	☐	☐	☐	☐	☐
4. Trustworthy with confidential information	☐	☐	☐	☐	☐

General

1. Conduct helps institution meet EEO commitment	☐	☐	☐	☐	☐
2. Supportive of institution's objectives	☐	☐	☐	☐	☐
3. Understands public relations aspect of job	☐	☐	☐	☐	☐
4. Aware and observant of institution's policies	☐	☐	☐	☐	☐

Supervisor's comments on strengths and weaknesses of employee's job performance and steps employee must take to improve:

Supervisor's signature **Date**

Employee's comments about this evaluation, the job, the supervisor, and in general about work at the University:

Employee's signature **Date**

Department Head's signature **Date**

CHAPTER 3

Employee Relations

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3.1 INTRODUCTION

Perhaps the single most important personnel service is that of employee relations. The fair and consistent treatment of employees, whether they belong to a union or not, is the objective of this personnel function. Responsibilities usually assigned to this function include the following:

- Development, revision, and communication of personnel policies or rules, including negotiation of labor contracts that are consistent with the goals of the organization, applicable federal and state laws, and modern management practices.
- Interpretation and administration of personnel policies, including administration of labor contracts.
- Peaceful resolution of grievances or complaints arising out of the interpretation or application of policies/rules and labor contracts.
- Administration of corrective discipline for misconduct.

These responsibilities of the employee relations function can be met only through the cooperation of all staff members, especially those in management or supervisory roles.

3.2 ESTABLISHING AND COMMUNICATING PERSONNEL POLICIES

Most universities and colleges have established written personnel policies/rules and procedures to assure the consistent and equitable treatment of employees. For employees who belong to a union, the labor contract defines most policy standards. Labor contracts are established through collective negotiations with the union representing the employees. This process is described in more detail later in this chapter. Personnel policies pertaining to nonunion employees are generally developed unilaterally by management, but care should be taken to assure conformance with organizational goals and applicable state and federal laws and regulations. Appendix 3-A is an example of a university policy guide pertaining to vacation time.

Labor Costs

After utilities, the next single biggest expenditure for plant manager is labor. How administrators deal with employees will have significant impact on the institution's operating budget.

With a commitment to nonunionism, managers must look seriously at employee groups and prepare job descriptions that are meaningful for the organization, incorporating the flexibility needed to administer the department effectively. When each of the individual job categories and probable assignments have been made, market surveys must be made for each position. Two factors of primary concern are wage levels and supplementary benefit packages. These are normally enumerated in a union contract and are matters for negotiation.

Once surveys are completed the facilities manager must determine where within the range of responses each item will fall. The plant budget cannot be excessive, and the facilities manager's goal is to provide an employee package that will attract good candidates and keep them in a college or university environment. An institution cannot offer extremely large compensation. But to be low would be noncompetitive, and the organization would be unable to attract or retain effective personnel.

A plant manager should know the available market of each employee group and should determine the combination of real benefits (wages, fringe benefits, insurance, etc.) and intangible benefits equal to that of organized groups in the immediate labor market. Educational assistance is a good benefit often found in colleges and universities. (For a more detailed discussion of wage and salary administration see Chapter 4.)

The important point is that when all the tangibles and intangibles are totaled, the employee package must be impressive enough to appeal to potential employees. Managers may need to create training programs for developing new employees, if the operations budget will not support the cost of experienced employees.

Grievance Procedure

Once the wage rates are established and employees recruited, managers must try to maintain the objective of staying nonunionized in order to be cost-effective. This does not come automatically. An effective grievance procedure must be developed, and the plant administrator must concentrate on the first step of the grievance procedure—how to avoid it.

The plant director must spend time with the crews and become sensitive to their needs, frustrations, and job-related problems. Employees need to know that the boss cares. Directors should look for potential grievance situation, and correct them before they become problems. If the director sees an employee violating safety procedures, for example, he or she should correct the employee privately, not in order to exercise authority, but to demonstrate genuine concern for the employee. The director must show interest and concern.

A labor agreement establishes the general framework of labor relations in the organization. It spells out in broad language the rights and benefits of employees, the obligations and rights of management and the protection and responsibilities of the union. At institutions without a union a similar book on policies, procedures, and benefit programs should be supplied by the personnel office.

Established policies and procedures should be kept current. Some existing policies and/or procedures may be obsolete or confusing. Rewrite them so they reflect what is important and relevant today. Keep them in simple, understandable language.

After the policies and procedures are updated and realistically presented, distribute them to all employees and supervisors. This is a good time to meet with supervisors to make sure they understand the content and application. Discuss the limits supervisors have in applying policies. Flexibility in application is not advisable. Fairness and consistency are the most important factors in the application of personnel policies.

Given the complexity of operating a plant department, the establishment of written personnel policies/rules and procedures specific to the department should also be considered. These should cover areas not included in institution-wide personnel policies. Appendix 3-B is an example of a departmental policy about the use of sick time.

Policies established through labor contracts are reviewed in subsequent negotiations and may be revised then. A periodic management review of personnel policies applied to employees not in a union is recommended. Most policies should be reviewed at least once every three years. Changes in methods of operation or applicable state and federal laws may require review and revision of a particular policy on a more frequent basis.

Communicating personnel policies is a major consideration. Without adequate communication, policies will not be consistently applied. Various ways to communicate policies and procedures include the following: institution and departmental handbooks, instution and departmental newsletters or papers, management memoranda, and staff meetings.

3.3 UNION RELATIONS

History and Legal Issues

Unionization and collective bargaining have been present in the United States for more than 100 years. The National Labor Relations Act of 1935 and its subsequent amendments have formalized procedures for employees in the private sector to organize and choose an exclusive bargaining representative (union) for the purpose of bargaining collectively with the employer over the "terms and conditions of employment." The law also allows employees to engage in concerted activities, principally engage in strikes.

The five-member National Labor Relations Board interprets and enforces the law. The regional offices of the board conduct representation elections (union or no-union) and certify the results. They also investigate Unfair Labor Practice charges (allegations of violations of the law).

Public Employees

Public employees are specifically exempted from the National Labor Relations Act (NLRA). However, few states now prohibit union participation and collective bargaining, and many states have adopted laws similar to the NLRA for their public employees. Most states do prohibit strikes. However, eight states as of 1979 granted a limited right to strike. Public universities and colleges should look to their particular state laws for further information.

Union Organizing

As mentioned before, employees of private institutions covered by the NLRA and those employed by public institutions with state laws patterned after the NLRA have the right to organize a union.

Union organizing efforts are initiated by interested employees who must file a petition with the NLRB (or the state agency in the case of public employees) for a certification election. Under NLRA rules at least 30 percent of the employees of the intended bargaining unit must sign the petition showing their interest in an election.

If a 30 percent show of interest is obtained, the NLRB or state commission orders an election. First, however, an appropriate bargaining unit must be determined. This determination, which is ultimately made by a federal or state agency, establishes which classifications will be represented by a union if it wins the election. The employer should look at this question carefully and negotiate with the NLRB or state agency to assure that the intended bargaining unit does not encompass too many or too few classifications.

If the intended bargaining unit contains employees with diverse interests, e.g., skilled trades and custodians, these employees are said to have no "community of interest." Bargaining over wages and working conditions with employees who have no "community of interest" is particularly difficult since disagreements within the union will commonly occur.

On the other hand, if the intended bargaining unit covers employees with very limited interest (e.g., all electricians) and excludes the other building trades, a "fragmentation of bargaining units" can occur, and the employer can be negotiating with as many as 15 to 20 different unions. Obviously this would cause a labor relations nightmare.

The employer must strive for a balance between these two extremes and prevent introduction of either a "fragmentation of bargaining units" or an all-encompassing bargaining unit with no "community of interest." Temporary and student employees should be excluded from the intended bargaining unit, as these employees rarely have a "community of interest" with the other employees.

When an appropriate bargaining unit is determined, the election will normally occur on the employer's premises. All employees within the intended bargaining unit are eligible to vote. A majority of those who vote determine the outcome, which is certified by the NLRB or state agency. Should the majority vote against unionizing, another petition for an election cannot be submitted for one year.

Once a petition is filed and accepted, management may decide to wage a campaign against unionization. This should be done only after legal consultation, since strict rules apply. A violation of these rules (the commission of an Unfair Labor Practice) could result in the election results being overturned and another election held.

Perhaps the most important thing for management to do is encourage participation in the election. Experience has proven that a large turnout usually favors management. Other tactics include keeping union organizing efforts and information out of work areas, and informational mailings to employees from management that discourage unionization. Again, these activities are strictly regulated. Always seek legal advice before acting.

Decertification Elections

Employees (not management) who are dissatisfied with their union can petition the NLRB or state agency (public employees) for a decertification election. A 30 percent show of interest is required before an election will be ordered. Similar to a certification election, the decertification election is determined by a majority of those who vote. If a union is decertified, and the unit becomes nonunion, no further unionization attempts can be made for one year.

Collective Negotiations

When a union becomes certified as the exclusive bargaining representative of a group of employees, management must then negotiate with the union over "terms and conditions of employment." Failure to bargain or "bargain in good faith" is a violation of the NLRA and/or state law if it was patterned after the federal law. This constitutes an Unfair Labor Practice.

As result of collective negotiations, agreements are usually written and a contract specifying the rights and responsibilities of both parties executed. Contracts vary in length but most often cover time periods of one to three years.

When the union makes a demand, management must respond to it if it is a mandatory subject of bargaining. Legal rulings have now determined approximately 70 mandatory bargaining items under the National Labor Relations Act. Many state laws are more restrictive, however. Those issues that are not mandatory are either voluntary bargaining items or illegal items. Illegal bargaining items are those forbidden by law. For instance, several states prohibit union shops or clauses in a contract that make membership in the union mandatory. Voluntary bargaining items have also been identified by both federal and state laws and are subjects about which management may either agree or refuse to bargain. One example is benefit increases for past retired employees. Legal advice should be sought when disputes over mandatory-voluntary bargaining subjects occur.

Under no circumstances does the duty to bargain equate with the duty to concede, or even compromise on a union demand. Even on mandatory bargaining items, management may bargain but decide not to agree on any contract language.

First-time contracts are important because they set the stage for future agreements. Therefore, management should obtain outside assistance in negotiating a first contract if no one within the organization has previous experience in this field.

Management's strategy during negotiations is usually to preserve as many management rights as possible and keep the overall costs of the contract within specific boundaries. A strong Management Rights clause is of utmost necessity to assure that subjects not discussed or agreed to during the negotiations remain firmly within management's discretion.

Failure to reach an agreement over a contract may result in a strike or the withholding of services of the employees covered by the union. Strikes by public employees are technically illegal in most states in the United States. In 1978 409 public employee strikes were reported, most of them illegal under the law. Management may decide to seek a court order to return illegal strikers to work, especially if the strike can be shown to be against the public interest.

3.4 IMPASSE RESOLUTION

Mediation

When collective negotiations fail to reach an agreement or contract, with little or no movement expected from either side, negotiations are said to be at an impasse. The federal and state governments offer, and in some cases mandate, assistance in breaking impasses and settling contracts without a strike. A federal or state mediator may come in, as a third party, to assist the parties in resolving the impasse. A mediator's only power is the power of persuasion. While he or she may make recommendations toward a settlement, the recommendations are not binding. The mediator's primary purpose is to keep the negotiations going and avoid locked positions by either party.

Interest Arbitration

Interest arbitration, on the other hand, is the use of an arbitrator to settle the contract, where the arbitrator (a third party) actually determines what the settlement will be. Some states have mandated interest arbitration for public employees engaged in crucial services--police and fire—to prevent strikes.

In several states the arbitrator must settle the impasse on the basis of the last best offer of the parties. Under this scheme, each party is encouraged to come up with a "reasonable" last offer.

Experience with interest arbitration has, at best, been mixed. Where procedures for interest arbitration exist, meaningful bargaining often stops with one or the other party opting for arbitration. Interest arbitration is considered by many labor relations experts as a circumvention of the bargaining process and against the public interest, since an outsider may ultimately settle the issue without regard to the public interest or settlement costs involved.

Fact-Finding

A third technique of impasse resolution in the public sector has been fact-finder. In fact-finding a third party, the fact-finder, analyzes the final positions of both parties and issues a public report based on his or her findings with or without recommendations for settlement. This is another technique that was hoped would cause the parties to establish reasonable positions on the issues, since their positions would be scrutinized by the public. As in interest arbitration, fact-finding has produced mixed results, at best. Many labor relations experts have criticized this process for many of the same reasons argued against interest arbitration.

3.5 GRIEVANCE PROCEDURES

The grievance procedure is a systematic, peaceful way to resolve an actual or alleged contract violation. The objective of all grievance procedures includes—

- Intention to settle an alleged contract violation case in a friendly and orderly manner.
- Specification of a series of definite steps to follow in the processing of grievances.
- Staying within time limits placed on each step.

- Answering a grievance within the allotted time (as specified in the contract).[1] The majority of all grievances are resolved in the first two steps. Most of the remaining grievances are resolved in the third step; however, a few grievances go to arbitration.

Most collective bargaining agreements outline procedures whereby the union or the employee may adjust grievances. A grievance procedure can act as a stabilizing force in the workplace, since it establishes a peaceful and orderly procedure for resolving disagreements. For this reason, many organizations have adopted grievance procedures for their nonunion or professional staff, too.

A grievance procedure is usually designed to assure a progressively higher level of review as the grievance moves from step to step. The concept is to encourage resolution of grievances at the lowest level (between the supervisor and employee), but also allow upper-level management review if the grievance is appealed. Time limits are usually established for each step to assure a timely resolution of the grievance.

In most cases, grievances begin with an employee requesting a steward to discuss a problem. The employee, now the grievant, meets with the steward and supervisor (as arranged by the supervisor) and presents his or her grievances. Should the employee fail to gain satisfaction, the grievance is appealed to the next level. Appendix 3-C is a grievance procedure used by a university for its nonunionized staff members. A grievance procedure should be available to all employee groups, whether they belong to a union or not. All employers need a means of resolving actual or perceived injustices. Failure to address these injustices would be counterproductive and lead to employee problems of the greatest magnitude.

Complex variables control the nature and frequency of grievances. Those variables are—

- The policies and discipline specified in the labor contract.
- Political environment and militancy of the local union.
- The calibre of the company's personnel administration and supervision.
- The nature of the existing union-management relationship.
- Economic and related variables affecting employment and working conditions.[2]

Supervisors and managers often find handling grievances a stressful and unrewarding experience. Because grievances are often filed against a supervisor or as a result of a supervisor's judgment, the supervisor may feel personally threatened. Employees, in many instances, also look upon the grievance as a struggle between them and the supervisor. This conflict between the supervisor and the employee can be greatly reduced, if not eliminated, if a supervisor remembers the following principles of grievance handling:

- Think of a grievance hearing as an investigatory interview. The object is to gather enough facts to understand and solve a problem.
- Let the employee and/or steward present the grievance. Managers must not assume knowledge of the grievance. Let the grievant and the steward tell their stories. Look for underlying reasons why the grievance was filed.
- Never argue with the grievant or steward. Even if managers disagree with what is being said, they should not comment. This principle defuses the conflict and shortens the length of the hearing.
- Ask for a citation of the specific violation of the contract or policy *and* a remedy.
- Ask questions to clarify the issue and gather essential facts.
- End the hearing after collecting all the facts. A gracious way to end a hearing is simply to say, "Do I have all the facts I need to make my decision?"
- Never answer the grievance at the hearing even if you know the answer or have reached a decision. Take time to consider the facts before responding to the grievant.
- Sell the answer to the grievant. A manager should tell the grievant the reasons for a decision. Allow the grievant some dignity even when the grievance is denied.

3.6 ARBITRATION

Arbitration is a process by which union and management agree to select an impartial person from a local, state, or federal list of arbitrators. Both groups agree that the arbitrator's decision is binding. An arbitrator views all pertinent material presented by the union and management and makes a determination on the *facts* presented.

An arbitration decision must be accepted. The decision to go to arbitration is a serious one. The results cannot be predetermined. Either side can lose.

> "Arbitration cases are not won on the basis of emotional appeals, theatrical gestures, or speechmaking. The arbitrator is interested in the facts, the evidence and the parties' arguments as they apply to the issues of the dispute. Such material should be developed in the hearing through careful questioning of witnesses and the presentation of relevant documents."[3]

Agreement to use of an arbitrator's binding decision has made drastic measures such as strikes and lockouts, which are costly in all respects, unnecessary. Peaceful settlements can be reached without disrupting the entire organization.

Some collective bargaining agreements specify that a grievance not resolved through the grievance procedure can be appealed to arbitration by the union. Arbitration is a costly procedure (usually over $1,000 per case) that calls for a disinterested party (the arbitrator) to decide the outcome of the grievance. Arbitrators use the collective bargaining agreements, past arbitration decisions, and their considerable experience in the field to make their determinations. The selection of arbitrators is a topic to be determined through contract negotiations. A popular method is to adopt the American Arbitration Association rules.

Almost all arbitration cases fall into two categories. The first category includes those questions about the interpretation or application of the bargaining agreement. These disputes arise when the union disagrees with management's administration of specific contract provisions. Management's preparation for this type of case should involve a thorough research of past negotiation minutes or notes. What was said during prior negotiations will be of primary importance, so detailed minutes or notes of each negotiation session should be kept indefinitely. In this type of case, the union has the burden of proof and presents its evidence and testimony first.

The second type of arbitration case involves the administration of discipline. Most contracts specify that discipline must be for "just cause." If the union disagrees with a disciplinary action taken by management and the grievance goes to arbitration, an arbitrator will decide whether the discipline was for "just cause" or excessive. In these cases, the credibility of the witness(es) is of prime consideration. Therefore management's witness(es) should be well prepared by an attorney prior to the hearing. In cases involving questions of discipline, management has the burden of proof and must proceed first.

3.7 CORRECTIVE DISCIPLINE PROCEDURES

An important factor for maintaining good employee relations is the consistent application of discipline standards. When misconduct occurs in the workplace, it disrupts the orderly and efficient operation of the organization. The supervisor must restore order to the workplace by administering discipline to the employee(s) involved.

Most modern organizations follow what is called a philosophy of corrective discipline. Discipline is administered to correct the behavior, not punish the employee for his or her misconduct.

Discipline for common misconduct, such as attendance and work performance problems, begins with an oral warning(s) or reprimand(s), then a written reprimand(s), a disciplinary layoff(s), and ultimately discharge/ termination.

More serious forms of misconduct, such as insubordination, may begin at a higher level with a written reprimand or a disciplinary layoff, and misconduct constituting uncorrectable behavior, theft and fighting—may result in immediate discharge.

Some employers choose to define, and even negotiate with their union's discipline standards, thus determining specific penalties for specific infractions of the rules. Others do not favor this "cookbook" approach and prefer to base the discipline on the facts of the individual case, taking into account any extenuating or mitigating circumstances. Either way, it is important to administer discipline consistently when similar situations exist.

Regardless of the size or nature of the institution, all organizations should use a corrective discipline procedure for misconduct. Employees who are unionized usually come under a "just cause" provision in their contract that more or less states that "employees will not be disciplined or discharged without just cause."

Corrective discipline helps assure that discharged employees were adequately warned and given a chance to correct their misconduct, thus documenting "just cause" for the discharge. This helps management win arbitration cases. The same care is suggested for nonunionized employees. Although they do not have the protection of a labor contract, they may decide to file discrimination charges or claim unemployment benefits for "wrongful discharge." Appenedix 3-D is an example of a university's discipline policy for nonunionized employees.

END NOTES

1. Arthur A. Sloan and Fred Witney, *Labor Relations*, 4th edition (New Jersey: Prentice-Hall, Inc., 1981).
2. Arthur A. Sloan and Fred Witney, *Labor Relations*.
3. Arthur A. Sloan and Fred Witney, *Labor Relations*.

Appendix 3-A

Standard Practice Guide

SECTION: Personnel
SUBJECT: Vacation
APPLIES TO: Regular Office and Technical Staff Members

I. Policy

To provide time off from work with pay for rest and personal convenience, the university provides regular staff members with paid vacation. Vacation time must be approved by the staff member's supervisor.

II. Regulations and Definitions

A. Accrual

1. Regular full-time staff members accrue paid vacation at their rates of compensation as follows:

First 5 years service (0–60 months)	1 day/month
Over 5 through 8 years service (61–96 months)	1½ days/month
Over 8 years service (97 months or more)	2 days/month

2. Part-time regular staff members normally scheduled to work eight (8) or more hours per week, accrue vacation time on a proportionate basis. Staff members normally scheduled to work less than 8 hours per week do not accrue paid vacation.
3. Vacation time accrues during time worked and during absences covered by Sick Time and Vacation.
4. Vacation days may not be accumulated in excess of twice the annual accrual.
5. Accrued time is available for use during the calendar month in which it is accrued.
6. Vacation accrual for partial calendar months of employment, (which can occur during first or last month of employment and during the month in which a leave of absence begins or ends) is calculated on the basis of the effective date of said occurrence according to the following table:

Effective Date	Start of Employment or Return from Leave	End of Employment or Start of Leave
1 through 10	100% accrual	no accrual
11 through 20	50% accrual	50% accrual
21 through end of month	no accrual	100% accrual

7. Except as provided in 6 above, staff members will not accrue any paid vacation time during any leave of absence or during any calendar month in which they are absent without pay for fifteen (15) or more working days. During any calendar month in which absence without pay is less than 15 but more than seven work days, the staff member will accrue 50 percent of the accrual provided in 1.
8. Increases in rate of accrual are effective on the first day of the month following completion of working time equivalent to five and eight years of continuous service.
9. Leaves of absence will be counted as time worked for the purpose of determining the appropriate rate of vacation accrual.
10. Time worked as overtime will not be counted when calculating accrual or rate of accrual.

B. Scheduling

Each department is responsible for scheduling vacations so as not to interfere with the operation of the department and so that each staff member receives his or her accrued vacation time each year, if he or she so desires. Vacations must, therefore, be scheduled to meet the work requirements of the department, but every effort will be made to satisfy the staff member's request. Units that experience "slack" or "down" periods may require that vacations be taken during these times. When practical, staff members should be informed of such requirements in advance.

C. Compensation for Vacation Time Off

A staff member who meets these regulations will receive regular compensation (rate at the time of absence plus shift premium, if applicable) times the number of hours of accrued paid vacation time scheduled and used based on his or her regular work schedule.

D. Pay in Lieu of Vacation

Actual time off work must be taken in order to receive compensation for accrued vacation time except upon:

1. Retirement.
2. Start of a military leave of absence.
3. Termination for any cause.
4. Quit without notice.
5. Resignation.
6. Death.
7. Layoff.
8. Reduction in hours (fraction) of appointment: If the hours (fraction) of an appointment are reduced, payment is made for all accrued vacation hours in excess of the maximum accrual eligibility for the reduced appointment. In the case of an interdepartmental transfer, the previous employing department will pay the excess accrual.

E. Advance Vacation Pay

Staff members who are paid monthly may request up to 50 percent of their regular gross monthly pay in advance. Staff members who are paid biweekly may request up to two weeks regular gross pay in advance. Complete the Vacation Payroll Advance Request form and obtain the signed approval on the form by the supervisor and/or the authorized signer for the department or organizational unit and present it to the payroll office. Supervisors and authorized signers cannot approve their own requests for advance vacation pay. To be eligible for an advance vacation payment, a staff member must—

1. Have accumulated the amount of vacation time being requested.
2. Request and take no less than ten (10) consecutive working days (holidays may be included).
3. Agree to have the advance deducted in one sum only from the next regular paycheck if paid

monthly, or one-half from each of the next two regularly scheduled paychecks if paid biweekly. (No other repayment plan can be arranged.)

Where applicable, supervisors may wish to double-check the amount of a staff member's accrued vacation time with the appropriate timekeeping office, e.g., Compensation Section, Personnel Office, Hospital Payroll, etc. (See sample form, Figure 3-1, attached.)

F. Probationary Period

Vacation time may not be granted during the probationary period.

G. Neither vacation time nor pay in lieu of vacation can be granted prior to the calendar month in which it accrued.

H. Holiday

A university holiday falling during a scheduled period of vacation will not be charged against accrued vacation unless it is one for which an employee has substituted a day of personal significance. In this case the university's designated holiday may be charged as vacation or excused absence without pay at the employee's option.

I. Vacation Time Substituted for Sick Time

At a staff member's request, absence due to illness or injury (as defined in Sick Time Policy) may be charged as vacation time in place of sick time. The time absent should be recorded as "S" (sick time) not "V" (vacation time) on the appropriate timekeeping document, and the box authorizing this substitution should also be checked.

J. Transfers

Unused vacation allowances will be transferred with an individual when transferring from one position, budget, or operating unit to another.

Staff members transferred from 12-month instructional staff appointments retain their accumulated vacation upon transfer based on maximum of one month less vacation actually used in the fiscal year in which the transfer occurs. They accrue vacation time from the date of their new appointment at the rate applicable to their new appointment. Staff members transferred to instructional staff appointments will receive pay in lieu of unused vacation.

Staff members involved in transfers should be encouraged to take their accumulated vacation prior to beginning their new appointments.

K. Vacation Benefits Phased Retirement

1. Staff members who are participating in Phased Retirement by reducing their hours of appointment will be paid for all accrued vacation in excess of the maximum accrual eligibility for the reduced appointment.
2. Staff members who are participating in Phased Retirement by taking a leave of absence for a fixed period of time will maintain vacation hours accrued, but not to exceed the maximum eligibility. Vacation hours do not accrue during the absence.

L. Long-Term Disability Plan

In order to be eligible for long-term disability benefits staff members must first exhaust their accrued vacation time, which will not be paid in a lump sum.

III. Procedure

A. Maximum Accrual Record

Responsibility	Action
Office maintaining permanent vacation accrual records.	1. Inform supervisor when staff member is approaching maximum accrual.
Supervisor	2. Assist staff member in scheduling time off in an effort to avoid reaching maximum accrual.

B. Vacation Accrual Records Maintenance

Responsibility	Action
Staff Member	1. Report all attendance as follows: a) If paid from account 20XXXX, report on Hospital Payroll Time Sheets to Hospital Payroll. b) If employed on an 090000 blanket account, report on prepared Accounting Time Sheet to Research Administration Accounting Timekeeping. c) If paid from non-20XXXX or non-090000 account and employed in the Medical Center, report on pre-punched card to Medical Center Staff Records. d) If employed in the Plant Housing, Michigan Union, Michigan League, Intercollegiate Athletics, University Library, Plant, Extension, Lawyer's Club, Alumni Association, Institute for Social Research, or Student Publications report to operational unit. e) If paid biweekly, follow departmental procedure. f) All other staff members report on pre-punched cards to Central Staff Records.

C. Transfer of Vacation Accrual Between Units

Responsibility	Action
Old department or office maintaining vacation accrual records.	1. Send an interunit transfer request to the Personnel Office in the office in the receiving unit.

D. Requesting Vacation Pay Advance

Responsibility	Action
Staff Member	1. Initiate Form 9791 Vacation Payroll Advance Request and complete necessary information for supervisor.

Supervisor	2. Check salary and accrued vacation of staff member.
	3. Check if amount of advance is 50 percent of gross salary or less.
	4. Check if vacation days requested are 10 or more consecutive working days.
	5. Sign form 9791 authorizing the Cashier's Office to pay the advance.
	6. If not an authorized signer for the organization unit, route the form to such person for signature.
	7. Retain supervisor's copy and give staff member his or her copy.
Staff Member	8. Take authorized form 9791 and University Identification Card to the Central Payroll Office or the Hospital Cashier's Office for payment.
Central Payroll Office or Hospital Cashier's Office	9. Pay staff member amount requested.
	10. Retain appropriate copy of form 9791. Hospital Cashier's Office: forward Payroll Copy to the Payroll Office.
Payroll Office	11. Deduct amount of the advance from staff member's next regular paycheck.
	12. Reimburse Hospital Cashier's Office.

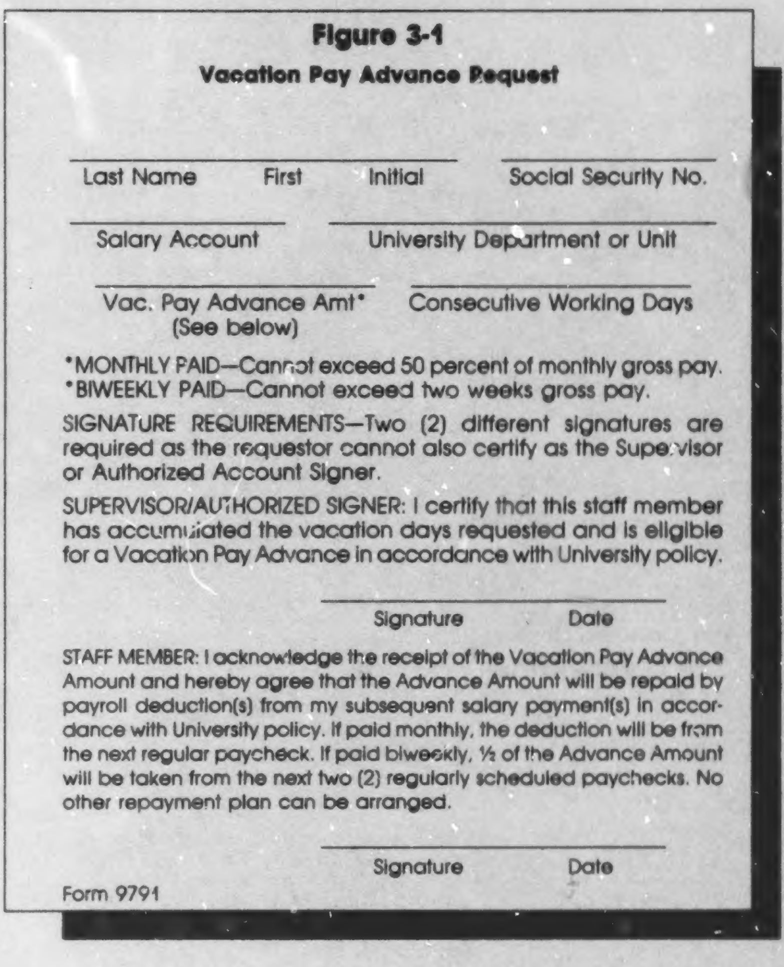

Figure 3-1

Vacation Pay Advance Request

Last Name First Initial | Social Security No.

Salary Account | University Department or Unit

Vac. Pay Advance Amt* (See below) | Consecutive Working Days

*MONTHLY PAID—Cannot exceed 50 percent of monthly gross pay.
*BIWEEKLY PAID—Cannot exceed two weeks gross pay.

SIGNATURE REQUIREMENTS—Two (2) different signatures are required as the requestor cannot also certify as the Supervisor or Authorized Account Signer.

SUPERVISOR/AUTHORIZED SIGNER: I certify that this staff member has accumulated the vacation days requested and is eligible for a Vacation Pay Advance in accordance with University policy.

Signature Date

STAFF MEMBER: I acknowledge the receipt of the Vacation Pay Advance Amount and hereby agree that the Advance Amount will be repaid by payroll deduction(s) from my subsequent salary payment(s) in accordance with University policy. If paid monthly, the deduction will be from the next regular paycheck. If paid biweekly, ½ of the Advance Amount will be taken from the next two (2) regularly scheduled paychecks. No other repayment plan can be arranged.

Signature Date

Form 9791

Appendix 3-B

Plant Department
Sick Time Usage Guidelines

All Plant Department employees are expected to meet a regular schedule of attendance. Employees who are unable to meet their employment obligation of regular and reasonable attendance and are excessively absent due to illness or injury shall be (1) counseled, (2) required to provide physician's evidence of disability, (3) provide a general medical evaluation of their ability to work, (4) attend a Sick Time Conference, and (5) may ultimately be discharged.

Absenteeism due to illness becomes excessive when it adversely affects our ability to maintain efficient service. It is the supervisor's responsibility to determine when an employee's absenteeism becomes excessive, but standards have been established to assist the supervisor in this effort.

Sick Time Standards for Plant Department Employees

Each separate or distinct absence is considered an occurrence. An absence of two or more consecutive days is still considered to be one occurrence. In determining whether an individual's sick time usage is excessive, the number of occurrences within specified time periods is used. Other factors to consider are total hours lost from work; patterns of absences, such as before and after weekends; preventive medical appointments; and on-the-job injuries.

The following chart may be consulted to determine whether an employee's absences are excessive based on Plant Department standards and what corrective action is recommended. Please note that occurrences of longer length (three or more consecutive days) require special consideration. Any unusual absences or factors should be discussed with your supervisor before taking action.

OCCURRENCES (of 1 or 2 days)	CORRECTIVE ACTION
3 or more occurrences in last 5 months	Counsel employee about employment obligation of regular attendance.
4 or more occurrences in last 6 months	Counsel employee again about problem and require employee to furnish physician's proof of disability for future

	absences. Employees covered by the AFSCME agreement will be given a copy of "Notice and Proof of Disability" (see Figure 3-2) with bottom box checked.
6 or more occurrences in last 12 months	Employee will be required to provide a general evaluation of their health on a one-page Physician's Statement (see Figure 3-3). A form letter and a record of their attendance is also attached.
After receipt of physician's statement	A Sick Time Conference will be held. Please contact the personnel officer before scheduling a Sick Time Conference. This conference is followed with a letter to the employee that confirms his or her employment obligation of meeting a regular and reasonable standard of attendance.
7 or more occurrences in last 12 months	Discharge. A Disciplinary Review Conference will be held prior to discharge in the case of AFSCME and trades employees.

These standards are guidelines only, and each employee's record should be discussed with your supervisor prior to taking any corrective action.

Physician's Excuse Guidelines

A supervisor or foreman may require an employee to provide a physician's statement under the following circumstances:

1. **When the supervisor has a reason to doubt that an employee is legitimately ill or injured.** Evidence of disability should be required when an employee has shown a pattern of frequent one- or two-day absences due to illness. Other examples include before or after a holiday or vacation, or when a vacation day is requested but denied. Please note that an employee can be required to provide a physician's excuse for absences of any length, even one day or less. However, this must be requested before the employee returns to work.

2. **When the supervisor needs additional information on the nature or length of disability.** When extended (three or more days) absences occur, a supervisor may require a physician's evaluation to determine what action should be taken, if any. This must be requested before the employee returns to work.
3. **To ascertain an employee's general health and ability to maintain his or her employment obligation of regular attendance.** Employees who are frequently absent will be required to provide a general evaluation of their health (one- or three-page medical statement, Figure 3-3). After this is provided, a Sick Time Conference will most likely be scheduled. Please refer to Plant Department Guidelines regarding sick time usage.

Those employees who are required to provide medical evidence of their disability or general health *shall do so at their own expense* unless we require them to see a physician of our choice. The Occupational Health Coordinator should be contacted to arrange those examinations where we require the employee to see a particular physician.

All physician's statements must include the following information:

1. **Name and signature of attending physician.** A nurse, secretary, or office manager cannot certify an employee's disability or general health.
2. **Date of examination.** An employee must provide evidence that he or she was seen by the physician on the date of the disability.
3. **Nature of illness or injury.**
4. **Duration of disability.** The statement must indicate that the employee was unable to work and for what duration.

Physician's excuses that do not provide the information listed should not be accepted. When a supervisor questions the validity of a doctor's excuse, he or she should contact the Personnel Manager immediately. Falsification of a physician's statement is grounds for discharge. Employees who are unable to provide the required evidence of disability shall receive an unexcused absence, which is subject to disciplinary action. Medical statements are to be submitted by the employee on the first day of his or her return to work. A copy of the statement should be sent to the Occupational Health Coordinator.

Special contractual requirements must be met when an employee covered by the AFSCME or Trades Agreement is required to provide proof of disability.

AFSCME

Employees covered by this agreement can be required to provide physician's evidence of disability by checking the box at the bottom of Form "Notice and Proof of Disability." This is done after an employee returns from a disability and has shown a pattern of frequent one- and two-day absences due to illness.

Trades

Employees covered by this agreement can only be required to provide a physician's proof of disability once prior to a Sick Time Conference. After an employee is asked to provide a physician's excuse, a Sick Time Conference can be held, and a six-month requirement to provide evidence of disability may be established. Please contact the personnel manager when this problem arises.

Preventive Medical Appointment Guidelines

Employees are encouraged to schedule their preventive medical appointments before or after work time. In those cases where this is not possible, sick time may be used.

Preventive medical treatment includes any medical treatment that is not an emergency and can be scheduled at the convenience of both the employee and the department. Routine medical or dental checkups, preventive treatments for a post-operative or ongoing medical condition, and cosmetic or minor corrective surgery are all considered examples of preventive medical care.

Employees may request sick time for preventive medical treatment by giving written notice of an appointment, name of the physician and duration of the appointment to their supervisor based on work requirements. In the event that emergency work requirements make it infeasible to release an employee for preventive medical treatment (even if appointment was scheduled five or more days in advance), the supervisor may require the employee to reschedule the appointment.

Employees who abuse this privilege will not be allowed to use sick time for preventive medical purposes.

Figure 3-2

Notice and Proof of Disability

(To be completed by employee upon return to work.)

NAME ______________________________ DATE ________
(Please print)

SOCIAL SECURITY NUMBER________________

I certify that I was unable to work because of a disability resulting from personal SICKNESS ☐ INJURY ☐

From: ________ Date ________ Time__________

To: ________ Date ________ Time__________

Total time lost from work in hours:____________________

Nature of Disability:________________________

____

____

____

☐ I was under the care of a physician.______________
Physician's Name

☐ I was not under the care of a physician.

☐ I gave advance notice to:______________________

☐ Time and date notice given:____________________

☐ I did not give advance notice because:____________

____

____

____
Signature of Employee

☐ Approved ☐ Disapproved Date________ By______________

Signature of Supervisor

Reasons for disapproval or other comments______________

☐ A physician's statement will be required as verification that you are unable to work because of personal sickness or injury prior to being considered for any future sickness or injury pay.

Figure 3-3

Employee's Authorization for Release of Medical Information

Doctor ____________________ Date ____________________

You are hereby authorized to supply (name of institution) with requested information regarding your findings as to my sickness or injury.

____________________ ____________________
(print name) (sign name)

(Detach for retention with patient's medical records)

PHYSICIAN'S STATEMENT

1. I examined ____________________ on ____________________
(patient's name) (date)

My diagnosis is:

(a) Date of injury or onset of illness ____________

(b) Date first consulted ____________

2. Based on this diagnosis* I believe that this patient is *able/unable* to perform his or her usual work on a full-time basis.

If the patient is currently unable to perform his or her regular work, when do you believe the patient will be able to do his or her usual work? ____________________________________

____

3. Other comments with respect to the patient's health as it may relate to his or her occupation?________________________

____

4. I would be willing to be called at ______________ for further information or clarification of this patient's status. ☐ yes ☐ no

Signed _________________________________
(Attending Physician)

Please return the completed form as soon as possible to:

*Note: If disability is the result of pregnancy and childbirth, the patient must be *physically unable* to do her usual work in order to be eligible to receive *paid sick leave*. If she is able to work but wishes to stay home with her newborn child, she will be granted a child care leave of absence.

Appendix 3-C

Standard Practice Guide

SECTION: Personnel
SUBJECT: Grievance Procedure
APPLIES TO: Regular Office and Technical, Professional, Administrative and Primary Staff Members except those covered by Approved Unit Grievance Procedures.

I. Policy

A staff member shall be afforded the opportunity to file a grievance on matters directly associated with the staff member's employment relationship with the university. Filing of a grievance will not cause any reflection on the individual's status as a staff member nor will it affect future employment, compensation, or work assignments. An allegation that a staff member's rights under this policy have been violated also will be subject to review under the grievance procedure.

II. Regulations and Definitions

A. Pre-Grievance Counseling

A representative of the Personnel Office or, in cases dealing with discrimination, a representative of the Affirmative Action Program Office will be available to counsel staff members who believe they have a grievance. Pre-grievance counseling is not judgmental. The role of the counselor is to help the grievant identify the source of the problem.

A Personnel Office representative provides the grievant with information concerning university policies and Standard Practice Guides, as well as protective laws and regulations related to the potential grievance. In cases dealing with a potential discrimination grievance, an Affirmative Action Program Office representative may also inform the grievant concerning university policies as well as protective laws and regulations as they may apply.

B. Pre-Grievance Resolution

The university will make a good-faith effort to seek resolution of a problem informally brought to the attention of the Personnel Office representative (in the case of alleged discrimination, to an Affirmative Action Program Office representative) through discussion and communication with the department or unit involved and with appropriate university officials.

C. Definition

The Grievance Procedure is a three-step review process whereby a staff member may exercise the right to address matters directly associated with his or her employment in accordance with the procedures set forth in this Standard Practice Guide.

D. Time Standards

Time limits set forth for filing and appealing grievances, holding review meetings, and issuing answers must be strictly followed. Mutually agreeable adjustments in holding a review meeting and in issuing an answer may be made due to the unavailability of a necessary party. In any event, such time limit adjustments shall not be in excess of five days beyond the stated limits. The grievance is considered withdrawn if the grievant fails to appear at a scheduled review meeting or does not appeal on a timely basis.

E. Modification

The university may modify the orderly progression from Steps 1 through 3 by reducing the number of steps for grievance resolution where the origin of the grievance, the operational unit involved, or the content and scope of the grievance makes the usual progression impractical.

F. Assistance in Review Meetings

A staff member may select any individual (except a staff member who is included in a university collective bargaining unit or the grievant's immediate supervisor) to assist in the review meetings at Steps 2 and 3. If the assistant is a university staff member, the assistant will not lose time or pay for attending meetings held during the assistant's normal working hours.

G. No Loss of Time or Pay

A staff member's attendance at a grievance review meeting held during normal working hours shall be with pay. Any other time spent in formulating or preparing a grievance shall be done outside the regular work schedule and shall be without compensation.

H. Discipline Grievances

Grievances concerning discharge or disciplinary layoff will be heard directly at Step 3.

I. University Grievance Review Committee

The University Grievance Review Committee will consist of the University Personnel Director, or Assistant to the Vice-President for Academic Affairs (or their designated representative) as Chairperson, the head of the operating unit in which the grieving staff member works (or a designated representative), and other staff members who may be deemed appropriate in the review process by the chairperson because of their special sensitivity or expertise. A representative of the General Counsel's Office will be available to advise the Review Committee.

When unlawful discrimination is alleged, the University Grievance Review Committee also will include a representative from the University Affirmative Action Programs Office.

J. Failure to Appeal

If a staff member does not appeal a grievance within the time requirement set forth in the procedure below, the grievance shall be considered settled on the basis of the university's last answer.

K. Liability

Except as otherwise specifically provided, the university shall not be liable on a grievance claiming back wages or other financial reimbursement for any period prior to thirty (30) calendar days prior to knowledge of the facts giving rise to the grievance.

III. Procedure

Responsibility	Action
Staff Member	Consider involvement in Pre-Grievance Counseling and Pre-Grievance Resolution.
Representative of the Personnel Office/Affirmative Action Program Office	Counsel the employee concerning university policies, practices, Standard Practice Guides, and protective laws and regulations.
Representative of the Personnel Office/Affirmative Action Program Office	Work to informally resolve a grievance. In no event shall this effort void the time limits established in the procedure outlined in this Standard Practice Guide.
Staff Member (Step 1)	1) Within 15 calendar days (30 calendar days if the grievant works with a representative of the Personnel Office/Affirmative Action Program to informally resolve a grievance) of knowledge of the facts giving rise to the grievance, discuss grievance with immediate supervisor.
Supervisor	2) Reply orally to staff member within three (3) mutual working days from date of discussion.
Staff Member (Step 2)	3) If not satisfied with oral answer, or none received within three (3) mutual working days, may appeal in writing to department head. a) Complete the grievance form. Obtain advice as needed from Staff and Union Relations.

b) Present the grievance form to department head (or equivalent level of supervisor) or his/her designated representative within seven (7) calendar days following a timely, but unsatisfactory answer or no answer at Step 1.

Department Head

4) Upon receipt of written appeal—

a) Notify Personnel Office representative and send copy of grievance.

b) Schedule review meeting and hear oral presentation of grievance within seven (7) calendar days of receipt of written grievance.

c) Provide staff member with a written response to grievance within seven (7) calendar days of review meeting.

Staff Member
(Step 3)

5) If not satisfied with the answer may appeal to the University Grievance Review Committee within fourteen (14) calendar days after receipt of Step 2 answer. If no Step 2 answer is received within seven (7) calendar days of review meeting, may appeal to the University Grievance Review Committee (grievance involving lost time, discipline, or discharge begins at Step 3).

a) Present the grievance form (including Step 2 answer) to the University Grievance Review Committee.

Chairperson—University Grievance Review Committee	6) Upon receipt of written appeal— a) Schedule review meeting within fourteen (14) calendar days of receipt of written grievance. b) Review the record and any additional pertinent new information. c) Answer grievance in writing within sixty (60) days from date of hearing [thirty (30) days when the grievant is appealing a discharge or a lost time disciplinary action]. If the grievance involves alleged unlawful discrimination, the answer will be reviewed by the president, with no extension of time, before being issued.
Staff Member	7) No further appeal is available unless unlawful discrimination is alleged (in which case appeal, if timely, may be to an external agency).

Appendix 3-D

Standard Practice Guide

SECTION: Personnel
SUBJECT: Discipline
APPLIES TO: Nonprobationary Regular Professional/Administrative, Primary, Office, Technical, and Service/Maintenance Staff Members

I. Policy

When staff conduct interferes with the orderly and efficient operation of the university, the university—when practical—will take corrective action that provides an opportunity for the staff member to change his or her conduct or attitude to avoid termination of employment.

II. Regulations and Definitions

A. Corrective Discipline.

The purpose of the discipline procedure is to provide a means of correction, not punishment.

B. Just Cause.

No disciplinary action, including discharge, will be taken without just cause.

C. Misconduct

Misconduct means conduct, whether by act or omission, that interferes with or affects in any way the orderly and efficient operation of the university. This includes any violation of rules and regulations or unsatisfactory work performance that is caused by other than a lack of capacity or ability, and off-duty behavior that adversely affects the employment relationship.

D. Suspension

Suspension is the interruption of active employment status (without compensation) pending investigation and a decision as to the extent of disciplinary action. Time off during a suspension may be considered part of a disciplinary layoff. The suspension should not be given for a predetermined period of time, but should last only long enough in the supervisor's judgment to permit time for investigation or cooling off or for the formulation of his or her decision after the investigation.

E. Oral Counseling

Oral counseling is discussion between the staff member and supervisor about the staff member's undesirable or unsatisfactory conduct or performance, including specific deficiencies or problems, corrective action required of the staff member, and the consequences of not complying with the expected standards of conduct.

F. Written Reprimand

A written reprimand should be in the form of a memorandum from the supervisor to the staff member, and a copy should be sent to Staff and Union Relations of the Personnel Office for the employee's personnel file. It will state the nature of the misconduct, what is required to change the conduct, by when the change must be made, and the consequences if the change is not made.

G. Disciplinary Layoff

Disciplinary layoff without compensation is a serious form of corrective action. It should only be used when supervision believes that by its use the staff member will correct his or her misconduct. In contrast to the suspension, the disciplinary layoff should be for a stated period of time but only of a duration sufficient to correct misconduct. It may range from the balance of a shift to several weeks. The staff member will be given a written statement of the reasons for the disciplinary layoff.

H. Discharge

Discharge is used when attempts to correct the employee's conduct have failed or when the improper conduct is of such a serious nature that the employment relationship should not be continued.

I. Grievances

Grievances processed by employees in the bargaining unit, which concern disciplinary layoff or discharge of nonprobationary employees, are subject to specific contract provisions. Complaints processed by non-bargaining staff members that concern disciplinary layoff or discharge of nonprobationary employees must be submitted directly at Step 3 of the complaint procedure.

J. Approval for Disciplinary Layoff or Discharge

No disciplinary action involving lost time and pay may be taken without the approval of the Staff and Union Relations section of the Personnel Office.

K. Staff Benefits if Discharged

When a staff member is discharged, the following conditions will apply to his or her staff benefits:

1. Staff members will be paid for vacation accrued at the time of discharge. In the case of staff members represented by a particular bargaining unit, specific contract provisions apply.
2. Sickness or injury disability income (sick time) that may have been accrued is canceled upon discharge.
3. Group life insurance will terminate the later of 31 days after the date of termination or at the end of the period through which premiums have been paid. During this period of time the discharged employee has conversion privileges.
4. Health insurance coverage will terminate at the end of the period for which the employee's payroll deduction pre-paid the insurance premium. During that period of time arrangements can be made to convert Blue Cross-Blue Shield Insurance to individual billing.
5. Travel accident insurance ceases upon discharge.
6. The same provisions of the retirement plans apply for terminations by resignation or discharge.

III. Procedure

The Disciplinary Process

Responsibility	Action
Supervisor	1. Investigate the circumstances surrounding the alleged misconduct and its consequences as completely as possible. Include discussion with the staff member if practicable. 2. Give a clear explanation to staff member concerning what he or she should have done, not done, or done differently, and how it should have been done. 3. If misconduct involved a violation of university rules and regulations, explain to the staff member what rules or regulations were violated and how. 4. If misconduct involved off-duty behavior adversely affecting the employment relationship, tell the staff member your understanding of the nature of the misconduct and how it adversely affects his or her employment relationship. 5. Determine appropriate disciplinary action in consultation with Staff and Union Relations Section. 6. If you decide after investigation that the unsatisfactory work performance of the employee is caused by his or her lack of capacity or ability rather than by misconduct, discuss transfer with the Staff and Union Relations Section.

7. If immediate removal of the staff member from university premises is necessary to prevent injury to himself, herself or others, disruption of work or other serious consequences, suspend him or her indefinitely without compensation during investigation.
   a. If the staff member is represented by a particular bargaining unit, specific contract provisions may also apply.

CHAPTER 4

Wage and Salary Administration

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4.1 INTRODUCTION

Although there are other significant motivators, wages and salaries are the current tangible rewards that employees receive. Wages and salaries are important to employees as indicators of their personal value to the employer and as a reference comparison between one employee and another. Consequently, wage and salary relationships can lead to employee dissatisfaction. A well-planned program of wage and salary administration is key to minimizing potential dissatisfaction of employees.

Typically, employees of the plant department are a small part of an institution's nonacademic staff and are subject to overall institutional personnel and fiscal management programs. However, since the plant manager is ultimately responsible for the results of the employees, it is important that the manager take a prime role to assure that the energies of the employees are not wasted through concern over wage and salary relationships.

This chapter discusses in detail two of the major structural elements of personnel administration of interest to plant employees—position descriptions and job classifications.

4.2 POSITION DESCRIPTIONS

The position description should clearly delineate the overall purpose and specific components of the position. It outlines the type and level of work, the hours, specific tasks, levels of authority and responsibilities, reporting relationships, and criteria for measurement of performance as well as the training and education that the job requires. Descriptions come primarily from the facilities office.

When preparing position descriptions, the plant director should consult with a variety of people, including employees presently occupying the positions, their supervisors, and personnel administrators. Since position descriptions cannot detail every task to be performed, they should include a statement to the effect that the employee "will perform other related tasks as assigned." Since work conditions change, the descriptions should be reviewed periodically and revised when necessary. The revision process can be coupled with an annual employee evaluation, which may result in re-classification of the job or upgrading of the employee position. A good practice is to ask those who helped prepare the originals, as well as current employees, to help in the revision. A sample position description is provided in Appendix 4-A.

4.3 JOB CLASSIFICATIONS

A job classification structure that groups positions with others having similar education, experience, and responsibilities in the same salary range is generally developed by the institution's personnel department.

This structure should reflect organizational reporting relationships and identify the sequence of positions available to employees for career mobility and advancement. Classifications need to be viewed as more than just titles. They should be part of a system that helps establish and clarify wage and salary levels, as well as levels of authority and responsibility. As the term suggests, classifications group positions with similar jobs paying comparable salaries. Classifications show salary ranges for each position (starting salary to maximum salary) and step increases, if applicable. If employees belong to a union, the classification lists wage levels as established in the union contract. A sample classification structure is included in Appendix 4-B.

Evaluation

In evaluating individual positions within a job category framework, administrators should carefully consider these factors:

For **exempt** positions (supervisory with hiring/firing authority)

- Knowledge.
- Planning.
- Creative thinking.
- Financial responsibility.
- Working relationships (contacts).
- Supervisory responsibility.

For **nonexempt** positions (non supervisory)

- Prior experience.
- Education and training.
- Complexity.
- Physical demand.
- Mental/visual/oral demand.
- Responsibility for records and reports.

- Relations with others.
- Confidential data.
- Equipment and supplies.
- Safety of others.
- Working conditions.
- Unavoidable hazards.

These elements can be used for an informal evaluation or may be weighted in some type of formalized point-factor analysis procedure.

4.4 WAGE AND SALARY RELATIONSHIPS

Physical plant administrators should pay more than casual attention to wage and salary relationships among employees. This is a matter of significant importance to employees. Personnel departments are usually objective, but the success of an organization depends on administrators adapting standard procedures to their organizational units. If managers look at their organizations, they will find the most sensitive salary relationships exist among employees within their own organizations or departments. This sensitivity to or awareness of compensation is higher within the group than with comparable positions outside the institution. Generally, administrators will find that the greater the physical and organizational distance between employees, the less compensation sensitivity there is among them.

Three Levels of Salary Relationships

One should look at the wage and salary relationships on at least three levels:

- Among employees of the same classification, e.g., electricians.
- Among employees of a larger work group who work side by side, e.g., technical shops (electricians, plumbers, HVAC mechanics).
- Among employees of the same major organizational unit, e.g., physical plant department.

Longevity and Other Factors

In addition to hourly wages and fringe benefits, employees are often sensitive to salary relationships that exist due to differences in longevity and increases due to merit or economic factors. Administrators may often unconsciously bring these differences to the attention of the employees. For example, the manner in which administrators present annual wage adjustments can emphasize salary differences rather than personal progress. Upper- level administrators and financial and personnel officers frequently view and fund annual increases on a percentage of the salary base. While this is logical and practical during the budget-cycle discussion, it can cause administrative problems. Percentage increases have a tendency to increase the differential between employees who are working side by side. Often employees who begin with a dollar or two differential see the gap widen from year to year, in spite of similar performances.

Salary Increase Programs

Salary structures in the education sector follow the long-established trend of recognizing that merit and longevity are the primary factors in setting salaries for a particular classification. Percentage increases tend to insert an extraneous factor, frequently causing unnecessary concern among the employees. One can eliminate this extraneous factor by administering merit increases to employees of similar classifications on a standardized cents-per-hour basis. For example, all electricians performing satisfactory work can be awarded the same amount-per-hour increase at annual salary review time. Likewise, those having better than satisfactory or less than satisfactory performance can be awarded a different but standardized increase.

To administer this principle across a large physical plant organization for unskilled and skilled trades, it may be necessary to develop different increase standards for different classifications. Normally different standardized increases will work, due to traditional differences in salary between the skilled and unskilled classifications. Administrators can use the average percentage increase (upon which funding is based) as a guide to providing employees having identical performance with approximately the same percentage increase in each of the classifications. The key to the success of the program is to discuss or present increases in terms of amounts-per-hour increases for each unit, not percentages.

If physical plant administrators want to reinforce departmental unity, then a standard economic adjustment (cost of living) factor (equal amount per hour) can be considered and applied for the whole department. In this case, the salary increase program could be made up of three parts

- Economic adjustment (same for everyone).
- Merit adjustment (equal amount per hour based on classification).
- Other adjustment (to compensate for salary mis alignments, etc.).

With the system described above, standard salary relationships among employees exist and controversy is reduced. However, with union contracts such flexibility to adjust salary relationships may not be possible.

Equal Pay for Equal Job Description

Another factor of interest and concern to employees is the practice unions outside the institution have of establishing equal pay for the same job description. Historically, the education community has rewarded employees for longevity, although longevity is now becoming less important to all workers, particularly younger ones. Where workers formerly readily accepted differences in salaries based on 10 years' difference in longevity, it is now important to consider equating salaries with as little as a five-year differential in longevity. Thus employees of a single classification with over five years' satisfactory service would make the same hourly rate. While this may ease the concern of the employee who has come from union membership, it does occasionally run counter to the standard university practice of rewarding for merit.

It is possible to have a grouping of experienced employees at one rate and still provide a system of justification where employees with exceptional merit can earn salaries above a standard maximum rate. Such a system must be carefully administered, however, so supervisors do not inadvertently move all employees to the higher rate within a few years. This dilutes the true merit implications of the rate. By adapting these guidelines to specific situations, the plant administrator can address and remove many employee concerns that interfere with their maximum effectiveness.

4.5 PAY POLICIES AND PROGRAMS

Two primary criteria beyond the requirements of basic federal or state law need to be used in determining pay policies and pay rates. They are labor market considerations and internal equity. Within these broad guidelines, it will probably be necessary to adopt specific programs, different in detail, for the exempt and nonexempt employee groups.

Comparative Surveys

Administrators need to conduct comparative market surveys, at least annually and occasionally more often in an active labor market, to maintain the institution's relative position in the marketplace. If the organizational salary philosophy is to be rated consistently in the top 10 percent of the defined labor market in the geographic area, the market survey data will show what changes (if any) are necessary to maintain salary levels according to the philosophy.

The plant administrator, not the personnel administrator, needs to monitor the results of market surveys for the plant staff. It is important for the plant manager to be vitally interested in all aspects of the pay policies and programs, since the effectiveness of the staff and the administrator's performance are at stake. Through close relationships with the personnel department and with staff, plant administrators can maintain the desired external and internal salary and benefits relationships.

Employees' Perceptions

Employees' actual perception of salary relationships is an important factor. Each employee should feel assured that the external and internal relationships are the best the institution can provide, and that both plant management and the institution are interested in these relationships. To establish credibility with the employees and to maintain this credibility, it may be desirable to include responsible and respected employees in the sample wage surveys and interviews conducted by the personnel department. Often the question arises as to whether real comparability exists between job classifications at one institution and those sampled at other institutions. It is important that the comparisons be equitable. Generally, the personnel department is not as closely attuned to a department's specific needs as is the physical plant manager. The facilities department can provide valuable assistance to the personnel department and to itself in these surveys by evaluating and comparing job descriptions of the department's employees with those surveyed.

Internal equity of salary relationships is even more important than equity with external employees. The process of determining internal equity can be informal or can be based upon a validated job analysis system that is appropriately ranked and rated by positions, in such a way that a non-discriminatory structure exists for the different positions within the organization. The personnel department should be able to assist in evaluating the internal equity of physical plant employees among themselves and with other employees of the institution.

Salary Increase Guidelines

It is common to establish salary increase guidelines for outstanding, above average, satisfactory, and unsatisfactory performance. The guidelines relate to the average and to percentage increases that will fit within the budgeted or available funds each year. As these funds change from year to year, the actual amount of increase will vary.

An exempt salary program should—

- Maintain a performance-driven (merit increase) program.
- Maintain expanded salary ranges to ensure potential for salary movement for individuals with outstanding long-term performance.
- Establish salary ranges allowing for competitive hiring and retention.

The nonexempt wage program should be evaluated periodically to ensure its simplicity with a minimum number of wage classification scales. In addition, the scales already established should be sufficiently broad to accommodate the large majority of salary requirements.

Pay and related policies need to be stated specifically for—

- Overtime.
- Shift differential.
- Holiday pay.
- Hazardous duty pay.
- Out-of-title work.
- Work week definition.
- Meal periods.
- Rest periods.

These policies should be given to employees at the initial department orientation. Updated copies should be posted at major employee bulletin boards so employees can refer to them easily. Records should be maintained in each employee's folder stating that the employee received and signed a copy of the policies. Supervisors need to review the policies periodically in their work unit staff meetings.

None of the policies and procedures described in this chapter will be completely effective if they are not understood by employees. Therefore, develop the policies to serve the best interests of both the employees and the institution. Then, sell the policies through good communication and fair administration.

Appendix 4-A

Position Description

CARPENTER

Function of Position

Shall be responsible for the installation, inspection, maintenance, and repair of architectural and structural elements of the building, including all wood products or associated equipment.

Qualifications and Experience

Shall have a high school diploma, or have completed accredited courses in trade school, or trade apprenticeship programs in carpentry and cabinet-making.

Five years of field or shop experience is required in the construction industries or building maintenance service.

Supervision

Shall be under the supervision of, and must report to, the shop or assistant shop foreman.

Duties and Responsibilities

Must observe safety regulations and policies.

Constructs hospital fixtures and special furniture, doing heavy remodeling work and millwork.

Performs all reglazing tasks within capabilities of shop tools and equipment, and according to recognized trade standards. Repairs furniture, including desks, tables, chairs, etc. Repairs locks and latches, also installs new locks as necessary. Repairs and replaces door checks, repairs various millwork such as mouldings, sashes, doors, cornices, floors, and stairways.

Keeps record of time spent per job and materials used.

Builds and installs lockers, cabinets, doors and partitions for offices, examining rooms, et cetera, as requisitioned. Does remodeling and alteration work. May lay new flooring of linoleum, asphalt, rubber or vinyl tyle. Patches floors of any type, replacing worn spots. Replaces sash balances cords and reglazes broken cords and reglazes broken sash.

May repair venetian blinds, installing new slats, tapes, and pull cords.

May repair and make roller type shades.

Through trade journals shall maintain knowledge of new methods, procedures, and materials used in work.

Shall assist in apprenticeship training programs.

May actively participate in hospital functional committees.

Performs additional duties as required, and if necessary works with associates to complete assignments.

May be asked to perform duties other than carpenter jobs, in case of emergencies or disasters.

Must maintain a professional attitude, be neat in appearance and well-groomed at all times, wearing the prescribed uniform.

Appendix 4-B

Classification Structure

Salary Scales for Fiscal Year 1982-83
Facilities Nonexempt Classification

Job Code	Job Title	Salary Steps Minimum		Hourly Maximum	
066023N	REFRIGERATION MECHANIC	1314	1379	1448	1520
066033N	AIR CONDITIONING MECHANIC	1314	1379	1448	1520
066043N	AUTOMOBILE MECHANIC	1314	1379	1448	1520
066093N	ELECTRICIAN	1314	1379	1448	1520
066113N	PAINTER	1314	1379	1448	1520
066123N	MASON/PLASTERER	1314	1379	1448	1520
066143N	CARPENTER	1314	1379	1448	1520
066153N	MASTER LOCKSMITH	1236	1296	1363	1421
066163N	PLUMBER	1314	1379	1448	1520
066183N	MAINTENANCE ENGINEER	1314	1379	1448	1520
066193N	PREVENTIVE MAINTENANCE MAN	1314	1379	1448	1520
066203N	MASTER MECHANIC	1329	1395	1464	1529
066223N	APPRENTICE LOCKSMITH	0967	1016	1067	1120
066263N	LEAD MECHANIC	1385	1454	1529	1594
066273N	LEAD CARPENTER	1385	1454	1529	1594
068003N	GARDENER	0801	0840	0884	0919
068013N	SR GARDENER	0841	0883	0927	0974
068023N	MAINTENANCE LABORER	0787	0826	0868	0904

CHAPTER 5

Training and Development

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5.1 INTRODUCTION

"You can't teach old dogs new tricks," but "you are never too old to learn." Proverbs and wise sayings offer little help when it comes to training, since they are either overly optimistic or unduly pessimistic about the possibilities of learning. Employee training is an effective management tool when used in a planned, purposeful manner. The need to train and develop personnel exists in every college and university work area, and the physical plant department has a unique opportunity to influence the entire institution with effective training programs for plant personnel. Because of the ever-present role the physical plant department plays in the overall operations of colleges and universities, the results of good personnel training will affect a broad spectrum of essential services, which in turn affect the quality of the teaching, research, and public service missions of higher education.

With proper training, facilities department personnel will be able to fulfill the department's many responsibilities. Trained personnel will be able to provide quality work, increase their productivity, and serve as a reserve of experience to handle emergencies. Training helps employees be more receptive and responsive and allows management more time for planning and scheduling work. Perhaps most importantly, proper training prepares employees for advancement and instills in them a desire to perform.

5.2 THE DIRECTOR'S RESPONSIBILITY

In order for any training program to be successful, a genuine commitment from the trainees involved and all levels of management is essential. This commitment requires management's active participation in total program development if the training program is to be effective. Immediate supervisors, especially, have an important influence on the motivation and development of staff. If the immediate supervisor does not support the training program, its ultimate failure will surely result. Any training program can only be as effective as the supervisors and other managers will allow. People believe much more in what they see than in what they hear. Supervisors and managers actively participating in training demonstrate involvement that is recognizable and persuasive.

People are generally motivated by their personal goals. They will take the initiative to acquire knowledge and skills needed to reach those goals. People are motivated by an organization's goals only if accomplishing the organization's goals helps them achieve their personal goals. In developing strategies for training, keep this principle in mind: training must be perceived by employees as part of their personal goals.

Departmental Organization and Management

A plant department at a large or small, public or private institution exists to provide goods and services the institution sees as worthwhile. To do this efficiently, the physical plant organization must function at the optimum level of productivity.

Training can solve a variety of manpower problems that work against optimum productivity. But in order to be successful, training must become a functional part of the department at almost every point within the organization. All that is needed is evidence of an operating problem that can be solved through training.

Often plant departments rely on the immediate supervisor to meet the department's training needs. Some supervisors have been successful as trainers/teachers, but results vary and are often unpredictable. Instruction is usually informal—sometimes on an if, when, and as-needed basis. It is limited to immediate on-the-job application and to one-on-one instruction. The supervisor works with a single subordinate. When first-line supervisors participate in training, especially in establishing standards and evaluating performances, this method is effective.

As an organization grows, so do the kinds and numbers of operating problems—thus an increase in the number of people needing training. A planned approach may be a better way of solving some operating problems. When managers and supervisors spend more and more time handling recurring problems, working with things instead of people, missing deadlines, and being pressed for time, then the department needs a structured program of employee development.

Budgeting Requirements

Training is expensive. It can tie up manpower, time, money, facilities, equipment, and supplies. It can disrupt work schedules. So when is training justified?

- When there is no better way to solve the operating problem.

- When the training is performance-oriented.
- When changes in the trainees' behavior can be measured, and the new behavior will be used on the job.
- When the program has been carefully structured and objectives are valid and clear.
- When instructors are capable, and equipment and facilities are adequate.

Physical plant operations at colleges and universities are labor intensive. An examination of plant operating budgets shows the largest percentage of operating funds are invested in personnel costs. Historically, throughout all campus departments, institutions are investing similar percentages of operating budgets to human resources.[1]

Staffing Requirements

Not many plant departments have staff available who themselves are skilled trainers. We lack the expertise that is essential to developing truly functional training programs for our departments. Most of us can identify the training needs. After identifying our training needs, professional skills are required to design courses and training materials and evaluate methods of presentation.

The plant director must take the initiative. Campus personnel officers or human resources development officers can and will help. If these professional services are available at your institution, use them. If the personnel office has a training officer, use this resource.

A successful training program can best be conducted by managers and supervisors who are close to the action. Knowledgeable managers and supervisors will be aware of the many ways training can be integrated into everyday work routines. They can also provide timely reinforcement and feedback. Other agencies or departments should be used as resources to help identify the training needs and carry the training program forward. Fundamental responsibility for training, however, rests with the director of facilities, the managers, and the plant supervisors.

Management Needs and Responsibilities

The physical plant department provides valuable and necessary services to the institution. To improve the effective delivery of services, training is used to increase or change the knowledge, skills, and attitudes of employees. The daily activities of the facilities department provide excellent learning opportunities, which can result in employee growth through the work process itself.

Plant directors are responsible for preparing their staff for, and making sure they are receptive to, change. The knowledge explosion has accelerated change in technology and human resource values. Engineers and technicians now require constant updating of knowledge, which once served a lifetime, just to stay employed. Skills learned in the past are obsolete, and large numbers of skilled and semiskilled employees must be trained to perform new processes and work with new products.

A college or university plant department performs a wide variety of operations. A departmental training program ensures that the many skills required to meet the operating needs of the institution are available. Whether managers train employees or not, employees learn. They learn by trial and error or from co-workers. Training goes on informally at all times. Any organized program will have a better chance of succeeding if it corresponds with—and grows from—existing informal training, experience, and actual operating practices.

Once a commitment to training is made, the program must be managed. The plant director must recognize that good planning is essential to effective training. Planning is based on department reviews of training needs and on constant reference to the plant department's goals.

5.3 DEFINE TRAINING GROUPS

Plant directors serious about training should look closely at the department organization and identify specific training needs.

One way to do this is to study the organizational chart. A typical physical plant organization has—

- An administrative level containing both line and staff positions.
- A managerial level of middle managers and/or superintendents.
- A supervisory level.
- A support staff level consisting of unskilled, semiskilled, and skilled employees.

Each of these levels has different training needs. In looking at the organization, recognize and be aware of the relationships among the different levels. Before pursuing one training approach, consider the consequences of training to each of the four levels within the organization. Not all employees will see a training program as beneficial. Leaders of the various organizational levels and individuals may not embrace the training program with enthusiasm.

	Positive Action	Negative Reaction
Support Staff/Trainee	Potential increase in compensation with possible promotion.	Labeled as a trainee.

Supervisor	Reduction in employee training needs.	Loss of control of employees.
Manager	Improved department performance.	Increased administrative duties.

Employees who may have a negative reaction to the training program can be persuaded to positive action if they are shown the benefits to them. Show employees what they can gain—the potential to work smarter not necessarily harder, the potential for promotion and increased pay, recognition, and cooperation from others through better work habits. It can also help to note that the training contains information gained from the experiences of other workers in similar jobs.

Support Staff

Support staff employees in physical plant departments can be defined as nonsupervisory employees. This staff consists of skilled, semiskilled, and nonskilled employees. Many jobs that require low skill at entry level, and some semiskilled jobs, fall within the custodial and grounds operations. Sometimes the requirements are for minimum formal education, 8th to 12th grades, with no previous experience. A willingness to work hard and report for work are the basic criteria for employee selection. On most campuses these positions compose the largest portion of the plant department.

The variety of assignments, duties, and responsibilities given to this group; the changing nature of their work; newer methods, materials, machinery, and equipment; the wide variances in quality of program commitment from institution to institution; geographic conditions; and ethnic makeup of the personnel are some of the reasons that a standard training program for this group does not exist. Unlike building trades, for instance, where apprenticeship standards have existed for decades and are standardized nationally, there are no apprenticeship standards or journeyman level skills clearly identified for the large number of employees working in nonskilled or semiskilled occupations.

Managers and Supervisors

Just as other training programs have varied goals, purposes, and objectives, management and supervisory training programs also need specific learning objectives. Determining these needs requires research and study. An organized plan helps determine the needs and measure results.

Training programs for these employees can be preventive (designed to prevent errors or problems) or corrective (designed to help solve a specific problem). Examples of some programs follow:

- Programs that provide orientation or basic training for new supervisors or managers—teaching them the basic knowledge and skills needed to do their jobs.
- Programs for managers that provide further training and additional skills needed to deal with people and the administrative elements of their jobs.
- Programs that communicate information about the organization and allow supervisors and managers to discuss organizational problems.
- Programs that provide information about new management theories, new concepts, and new approaches to solving management problems.

5.4 IDENTIFY TRAINING NEEDS OF SUPPORT STAFF

Identification of training needs is the first step in embarking on any training program. The needs of the institution and the needs of the individual must be carefully balanced. The plant director must identify the training programs that will improve employee skills, abilities, and job performance. Because formal training and development programs have not been widely used for staff employees in higher education, it is possible that supervisors and managers themselves are unaware of the kinds of programs that are needed. Most physical plant departments do not have personnel who are skilled at applying methods of systematically and comprehensively identifying the training needs of employees.

Surveys

As always the solution begins with identifying the problem. Structure the training program by first identifying the training needs. A simple survey instrument can identify existing skill gaps. The survey should list a series of basic training programs that could be offered. The results of a needs survey might identify areas such as the following that would improve the organization:

- Orientation.
- On-the-job training.
- Apprentice training.
- Training by job rotation.
- Lecture and classroom training.
- Case studies, role playing, and skills practice.
- Programmed study and other available methods.

Supervisors and/or managers can select programs that would be most beneficial to employees in their units. In addition, the survey form should solicit ideas for other programs that supervisors believe would benefit their departments.

Specific problems that can be corrected with a training program can be listed on the survey form. Using a survey saves time and is efficient. Once employees complete the survey, managers must separate the wants from the real needs. Then priorities can be established based on the greatest need and available resources. Realistic and practical considerations should determine the choice of programs.

Jobs Analysis

For the purpose of identifying training needs, different ways of collecting job information are available. Following are seven effective methods that all plant departments can use and that require no special skills beyond the capabilities of supervisors and managers.

Work Sampling and Observation Are there obvious evidences of low productivity and inefficiencies such as excessive lost time, damage to tools and property, poor methods, large numbers of grievances with high absenteeism, or excessive turnover? Are there dramatic incidents by individuals or a group that reveal poor personal relationships, frustrations, lack of understanding, or personal limitations? Other such questions can be raised from simple observation of the work being performed. Take time to ask, "What's going on?"

Management Requests for Training Have you observed something wrong that training can correct? Are there situations where training will help employees work smarter? Has the boss suggested areas where employee performance, improvement, or special skills are needed? If training were provided, are there opportunities for promotion and advancement within the department?

Interviews Interviews with supervisors and employees are helpful. Discuss problems encountered during the work day and how employees feel about their need for training. Interviews work well in conjunction with surveys to identify training needs. The combined methods help accumulate information about work problems.

Group Conferences Discussing the institution's mission, the department's organizational objectives, and operational problems associated with the department's commitment to training can be of value. Managers may respond to open-ended questions such as: What kinds of difficulties do you have obtaining qualified candidates for a particular job? How can we produce qualified candidates from within the organization?

Comparative Studies Compare good performance with poor performance and the employees involved. Determine the criteria to be used for differentiating successful from unsuccessful performance. Was the work performed in accordance with acceptable standards, including costs of labor and materials? Was it completed on schedule with minimal disruption and inconvenience? Was the customer/client satisfied?

Regular lawn mowing and trimming provide a good example of this process. A lawn area maintained by a good performer will be mowed at the proper time (without disruption of scheduled activities on the lawn area or in adjacent buildings), with the correct equipment at the prescribed height, after paper and debris have been removed, grass trimmed around trees at the same height as the lawn was mowed, edged, and sidewalks cleaned of clippings.

Supervisors' Reports Performance reports, if administered in accordance with good personnel practices, can be most helpful in identifying employee training needs. Periodic employee job performance reviews should always address the employee's job knowledge and, therefore, provide another opportunity for identifying training needs.

Literature and Reviews Read trade journals and magazines for abilities and skills each job requires to keep employees active in the field.

Manpower Analysis

Manpower analysis focuses on the individual in a given job, rather than on the job itself. This type of analysis occurs in regular employee evaluations—when a supervisor discusses performance with an employee. (If supervisors do not regularly review performance, a training need exists for supervisors.) Three basic issues are involved with manpower analysis for training purposes.

Evaluation and Identification Through appropriate observation, supervisory evaluation, and testing methods, managers determine that performance is standard and acceptable and/or that training is needed.

Priority We need to ask whether physical modifications of the job may bring an employee's performance to acceptable standards, or if new equipment or processes may be the solution.

Tests, Inspections, Reports Job knowledge tests, work inspections, and performance reports provide useful information with which to develop training programs. Through such means, a group of custodial employees could be accurately identified the second week on the job as either fast or slow in performance. Individuals needing additional training could be readily identified.

If the training program is to remain current and viable, the kinds of analyses described above must be continuous. To maintain physical plant organizational life, administrators must review and revise the training program to reflect changes in the department's resources, objectives, internal organizational climate, and the institution's goals. Clear identification of training needs cannot be done in isolation and without observation. Training programs must be integrated with daily work and carefully designed and executed.

5.5 IDENTIFY TRAINING NEEDS OF SUPERVISORS AND MANAGERS

Few institutions have the ability to conduct all supervisory and management training with in-house staff. Many institutions lack the resources to hire or send management and supervisory personnel to effective training programs. However, training is essential to the continued success of any plant department. Directors must meet this challenge.

Begin by outlining carefully the supervisory and management training needs. Identify those needs by reviewing the responsibilities of each supervisory and management position. Most of these positions will fall into one of four categories:

- New first-line manager or supervisor.
- Experienced first-line manager or supervisor.
- New manager of managers (middle manager).
- Experienced manager of managers.

Personnel in each of these categories have different needs for training to help them fulfill their responsibilities.

New Managers and Supervisors

The most critical training is that which is provided newly promoted supervisors or managers. These new supervisors must develop appropriate viewpoints and attitudes. They must be given the tools of their new role immediately to ensure their success. New managers and supervisors should understand their roles, their authority and responsibility, the performance expected of them, the policies and practices of the institution and department, their budgetary and operating responsibilities, legal regulations, and union/management relationships. They must also be familiar with the most current theories of motivation and leadership. Training should include use of supervisory skills and management of human relations.

The role of new supervisors is difficult and many worry about making mistakes. The change from an employee to a member of management must be thoroughly discussed and understood. It creates new relationships, because the new supervisor is now responsible for getting work done through other people.

Effective supervisory training can be successful only when the task is approached with a clear understanding that the supervisor is part of management. As a key link in the chain of management and labor, the supervisor must translate into actual results the plans and goals of the physical plant organization.

Supervisory training should be included as a part of the physical plant department's programs for management development. Directors of facilities must make known their philosophy of departmental organization. Directors must pay special attention to their spoken and written words on policies and practices for management development.

Creating a written statement of the goals of supervisory and management development may be helpful. Management development is a continuing process. It is worth the time and effort required to construct a program that develops good management practices, continual refreshment, continual rededication to the department's mission.

New Managers of Managers

Equally important is training new members of middle management, so they will understand and be able to meet their responsibilities. It should be clearly understood that their role is to instruct their subordinate supervisors and that they will be held accountable for this effort.The training of new middle managers should have a high priority and must be given the same careful attention as the training of new supervisors.

Training new middle managers should give emphasis to understanding the interaction between department organizational units, resolving conflicts, managing and implementing change, organizing and controlling work, budgeting, and using numerical data and other management tools.

Members of middle management need greater organizational knowledge and information in order to understand better the interaction needed between functions and the impact of decisions on the overall organization. Delegation, problem analysis and decision making, coaching and training subordinate supervisors, and conducting meetings are skills needing increased attention in middle management training.

Middle managers have a responsibility to ensure uniformity in the supervision of people in different units. This uniformity applies to fair budgetary standards, performance standards, and operating results. Middle managers should have the opportunity to gain a better understanding of current department-wide problems, and a chance to participate in solving those problems.

Experienced Managers and Supervisors

Management and supervisory training is not a one-time activity. Organizations must provide additional training beyond the basics necessary for new supervisors and managers, so experienced employees may acquire new skills and remain current in their fields and in the art of management. The director must give careful attention to developing an overall plan for development of supervisors and managers to ensure that training will occur periodically. Middle managers must be aware of policies and practices, and they must learn new and improved skills and techniques for enhancing employee relations and solving operating problems.

Supervisors and managers should be encouraged to continue their self-development. If each management and professional person in the organization has at least one formal learning experience each year, the organization will have established a career pathway that will help ensure that staff members are well informed, that they have credibility and acceptance in their field, and that their input and influence on departmental decisions is valuable.

5.6 PLANNING THE TRAINING PROGRAM

When planning a training program, the program developer needs to answer such questions as—

- What should be done?
- In what sequence?
- When?
- How?
- For whom?
- At what cost?
- What specific results can be expected?
- What constraints are present?
- What problems must be resolved?

Plans must be developed carefully with ideas from all persons responsible for, and contributing to, training. Answers to these types of questions will help the training plan move forward.

Ingredients of a Quality Program

The structure of a comprehensive supervisory and management program is complicated and requires a professional and continuous effort. Before deciding whether to use in-house contracted trainers, give serious consideration to the essential ingredients of a quality and continuous program of supervisory and management training.

Definite Objective The program should be designed to bring about worthwhile improvements in the performance and productivity of the organization, with aims sufficiently well defined to permit measurement of results.

Relevancy The program contents should be pertinent to the participants' needs in relation to their particular jobs within the organization. There is a difference in the needs of new first-line managers and supervisors as opposed to experienced first-line managers and supervisors. The program should deal with that which is germane and current, not with things that are merely nice to know.

Substantiality The program should treat subject matter in sufficient depth and with sufficient comprehensiveness to bring about noticeable improvements in behavior. It should avoid mere verbalization and orientation information unless absolutely essential. The natural resistance to change must be recognized.

Leadership Instructors or discussion leaders must be competent in their particular fields, skilled at imparting knowledge, and able to communicate. Individuals whose performances set examples worthy of emulation are effective leaders. The motivation of the manager to apply learning on the job is a key consideration.

Appropriate Level The program should be designed with a realistic awareness of the qualities, backgrounds, and capabilities of the participants. It should be neither too elementary nor too advanced. The principles of adult learning should be used. Training experts explain that persons responsible for the development of training programs for supervisors and managers must not only be educators, but also adult educators. Adult educators understand that an effective environment for adult learning must be created.

A successful training climate implies a willingness on the employer's part to meet the employee on his or her own interest and experience level. An effective trainer recognizes that adult education requires technical competence, as well as knowledge and understanding of the employees as individuals—their standard of living, cultural assumptions, and the nature of their communities. Effective teaching of adults depends on shared learning, individual contact, and carefully delivered demonstrations.

If the above ingredients are included in the program, it can sustain critical scrutiny and evaluation. It will be worth more than it costs, because it will increase the value of supervisors and managers to the organization.

Methods and Applications

Standardized Programs Excellent programs are available that can be tailored to specific needs. Some training programs produced by commercial and professional training companies can be adapted. Using canned programs, with changes carefully considered to meet a particular need, is a good way to get training programs started. However, directors should not view these existing programs as an easy way to meet departmental training needs. The need for training, the specific areas to be emphasized, and the results expected must be carefully considered.

Self-Instruction Another method of in-house training for support staff employees uses self-instructional training programs conducted on campus. Several companies specialize in this type of programmed learning. These companies offer excellent course materials designed and directed toward individuals with responsibility for maintaining facilities. The Association of Physical Plant Administrators of Universities and Colleges can provide information on these programs.

In-House Programs A number of colleges and universities have developed their own training programs. The plant departments at these institutions must not be overlooked as a source for in-house training programs. Many campuses have successfully produced slide tape productions and videotape programs using their own staff.

Workshops and Seminars Presented by professional associations, colleges, and universities, workshops and seminars are another source for support staff training. Courses on particular subjects are taught and sponsored by professional associations and offered through continuing education programs at many colleges and universities. Seminars from APPA provide a source of training on a wide variety of subjects at many locations throughout the country. Workshops sponsored by several institutions can provide inexpensive and timely training for plant staff. A good method of obtaining training for employees is for the institution to host or sponsor a training program.

After identifying a specific need for training, training coordinators may find other institutions with similar needs. If so, these institutions may conduct a training program together. The expense of such programs for instructors and training materials can be shared with, or passed on to, another institution whose employees are attending. Thus training can be obtained at reasonable costs.

Programs sponsored by chapter, regional, and state APPA groups are excellent avenues for continued staff training.

Training for Special Skills Manufacturers and companies whose products, equipment, or systems the institution uses can provide training for special skills. This is an excellent source for employee training to meet specific needs. Most manufacturers are willing and eager to cooperate in product training.

Training for computer program and equipment use, energy management system operation, environmental controls, lighting, irrigation, and special equipment operation are frequently coordinated with manufacturer and supplier training.

Apprentice Training The oldest vocational and technical training system in the United States is the apprenticeship. It evolved directly from the medieval guild system and has wide applications to vocational and technical training needs. Apprenticeship training flourishes where employee unions flourish. Such training is often administered by a union-management joint apprenticeship committee.

There are, however, several institutions with excellent apprentice training programs administered solely by the plant department. These programs can be developed with standards equal to or exceeding the federal or state standards for apprenticeship training. Programs meeting these standards may be registered, and graduates can be given certificates of completion by the appropriate agencies. In developing an apprentice program, begin with a review of the federal and state laws governing apprenticeship standards.

On many campuses a need exists for a number of positions that can be described as trades generalist or crafts/maintenance. Employees in these positions spend a substantial amount of time performing a variety of different tasks that cross over many of the specialty crafts such as plumbing, painting, carpentry, and electrical. In-house apprentice programs can be designed to meet this need. Additionally, an in-house apprentice program will broaden the applicant pool for those institutions finding it difficult to attract qualified women and minorities to journey-level craft jobs. The apprentice program can also provide upward mobility for many employees. This can be especially effective for employees in classes such as custodian, laborer, and groundsworker.

5.7 IMPLEMENTING THE TRAINING PROGRAM

Instructors

Selection of instructors is critical. Certain subjects can best be taught by trained managers, while some require the use of professionals and consultants. The use of managers improves the communication process and improves the supervisors' and managers' understanding of the particular views of other department managers and the director. The director's involvement as an instructor reinforces the commitment of the organization to the development of managers and is encouraged.

Staff trainers may not have the background to cope with the diversified technologies of the physical plant. The institution may not have the resources to deal with the logistics of training large numbers of people, changing technologies, and campus-wide dispersements of plant personnel. A successfully proven solution uses the personnel staff or professional trainer to train supervisors and managers to become trainers.

Train-the-trainer programs can be tailored to a specific need. Often the search for technically qualified trainers leads back to the supervisors. Training supervisors to train can result in well-qualified persons who can do training within the facilities department. Some institutions in the same geographic area have shared the costs for professional training personnel.

It is practically impossible to find one person to do training for all areas of the department. But one individual—whether from the personnel office, the plant staff, or a hired consultant—can function as a program creator or coordinator. The program coordinator may actually present and train as well. One person can handle employee orientation and use the expertise of supervisors and managers to design, develop, and conduct specific training programs. Training consultants and formal technical training programs can supplement on-campus expertise. One person can coordinate these resources and produce a training program tailored to a particular organization's need.

Department Orientation

No matter what level of the department organization is being considered for training, a process common to all employees is orientation. Sometime between accepting a job and receiving the first pay increase, employees undergo orientation. During this period new employees become a part of the organization. Ideally they will have adopted, or at least been exposed to, the department's point of view. New employees' first months with an organization have greater influence on their future than any other employment period. New employees have the highest visibility then, and they are searching for a pattern of behavior that will give them the results they seek. Through orientation new employees can acquire a commitment to the organization.

Employee orientation cannot be overlooked in considering the training needs of facilities employees. An employee orientation booklet and a supervisor's guide to employee orientation can contribute much to orientation. *The Employee Orientation Booklet* and *Employee Orientation—Responsibilities of the New Employee's Supervisor* used by California State University, Northridge, are good examples of this.

A valid orientation program will foster a positive outlook among employees, which will pay dividends when initiating future training programs.

An orientation program should—

- Motivate employees to succeed at the job for which they were hired or instill in employees a desire to succeed at a level higher than the one at which they entered the department.
- Develop a feeling of belonging and a sense of satisfaction in being a member of the department.
- Encourage a commitment to department goals.

- Create an acceptable level of conformity to the department's formal and informal rules of behavior.

Because of the widely dispersed and different activities of plant departments, the employee's immediate supervisor is best suited for conducting the orientation program. An orientation plan can be built for each new employee. In its simplest form the plan is the supervisor's checklist of the criteria for successful orientation.

This checklist could include such items as—

- An explanation of the institution's organizational structure.
- An explanation of the plant department's organizational structure.
- An introduction of new employees to the director, managers, and supervisors.
- A visit to the personnel office for completing the necessary forms and for explanation and receipt of the benefit packet and information.
- A review of the facilities department's rules and regulations, including work hours, break times, lunch area, and procedures for recording work time.
- An introduction to other plant employees with whom new employees will work.
- Description of the duties of the position. A job duty statement or position description is useful.
- Explanation of materials, equipment, and vehicles new employees will use on the job.
- Provision of keys, name tag, identification, work uniforms as needed and appropriate.
- Information about pay and eligibility for merit salary increases. Explanation of when, from whom, and how paychecks are issued.
- Other items the supervisors identify as helpful in orienting new employees to the workplace and that will assist new employees reach their full working potential in a minimun but reasonable time.

5.8 CONCLUSION

The operation of a plant department is complex and ever-changing. We cannot afford to be without training. Nor can we merely provide lip service to the important obligations we have to our managers and supervisors. We must be willing to invest money, resources, and manpower to meet the demands of the organizations we serve.

END NOTE

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CHAPTER 6

Principles of Motivation and Leadership

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6.1 INTRODUCTION

Managers and teachers of management generally agree that applying sound leadership and motivational techniques can substantially improve performance of any organizational unit. This chapter looks at leadership and motivation in the physical plant environment and suggests tested techniques that, when applied, should improve the performance of an organizational unit. These techniques should be more useful than ever before to facilities managers because of the budget constraints facing many colleges and universities. Most educational institutions are currently going through difficult economic times, and the plant department should expect to bear its share of that budgetary pressure. To meet those expectations plant managers need to increase the productivity of fewer resources. During the past 20 years there has been an increasing tendency to recognize people as an important resource to the organization—an asset that represents considerable potential for cost reduction and efficiency improvement. Through proper management techniques, cost reductions and efficiency improvements of the people resource can be realized.

Facilities departments play a strategic role in attaining the goals of a modern university or college. In the face of potentially declining enrollments, the appearance of the buildings and grounds and the overall condition of the institution's facility can influence a particular student's choice or an alumni's contribution. An effective plant department can contribute directly to enrollment. The general appearance of the facility may either encourage or discourage students' pride in their school, and it may determine whether they recommend the school to others. There is no question that an efficient and effective plant operation is vitally important.

6.2 UNDERSTANDING PEOPLE

When individuals are promoted from a nonmanagerial to a managerial position in an organization or hired from off the campus and given managerial responsibility, they must immediately be concerned with accomplishing work through others. This represents one of the unique aspects of the managerial job. Nonmanagers are basically responsive. Their major concerns revolve around understanding the orders that are given to them, recognizing the importance of the orders, and determining how best they will accomplish them. But the manager's job is much more complex than that. Although managers need to understand their own jobs and have a basic knowledge of the job assignments given to others, there is the additional complex ingredient of being responsible for the work of others. As managers, our bosses often hold us accountable for that work. And our own progress and personal success will be measured in large part by how well that work is carried out by others. Clearly, our success as managers, and a major portion of the overall success of our organizational units, is determined by how well we can get others to perform that work effectively. This is the motivational problem that faces the plant manager. While this is a complex and challenging problem, it is not an insoluble one. Many managers welcome the challenge of motivating others.

In assuming managerial responsibility, we must try to understand the behavior of others as well as our own. Nonmanagers are permitted the luxury of only worrying about their own behavior and the behavior of others as it influences them. A critical part of the managerial job is understanding how others react to the organization, management, and management practices.

Key Factors That Determine Employee Behavior

There are several common elements that directly affect the behavior patterns of people in facilities organizations. The three most important elements follow:

Culture Culture can be defined as a value system or mode of behavior to which people in a given geographical area subscribe. Virtually all behavior in any organization is culturally bound. Since the United States' culture is heavily characterized by individual competition and has historically been an achievement-oriented society, workers tend to expect opportunities to advance, and they respond to rewards for individual accomplishments.

Paternalistic management practices have been accepted in certain oriental cultures but may not work well in the United States. These practices are particularly questionable in those areas of plant management where highly trained engineering functions are involved or where employees have trained specialties. Individual accomplishment and achievement flourishes in an environment that fosters recognition and reward.

Plant managers need also to recognize that subcultural differences dictated by varying geographical locations can affect management style and motivation. For example, employees in small colleges and rural areas may respond more favorably to paternalistic management than will employees in large universities located in urban environments.

Perception Perceptions relate to how we see the world around us and to how we see ourselves. People tend to behave in accordance with their perceptions. For example, if plant employees see themselves and their role in the university or college environment as considerably less important than the role of faculty or other administrative groups, their motivational potential and actual performance is likely to be affected. The facilities manager must continually stress the important role of the department to the overall institution's goal and mission. The facilities manager must favorably influence the perception of employees with regard to the importance and contributions both their work and job performance make to attaining the institution's mission. Objective perceptions by outside observers are not relevant to individual behavior in an organizational setting. More specifically, behavior is determined by what each employee sees as relevant and is not greatly affected by what outside observers perceive as reality. Thus, reality to the employee is the way he or she sees the environment, not the way outsiders see the environment. Managers are often more sensitive to the perceptions of outsiders with regard to their environment rather than to the perceptions of their own employees. If this sensitivity is directed more towards individual employee perceptions, managerial action can be adjusted to correct problems before they become serious.

Status An important factor that influences behavior in the plant environment is the perceived status of individuals relative to each other. Americans are particularly sensitive to status perceptions, and most employees want to be ranked higher rather than lower. Status is a hierarchical ranking or ordering of individuals as either being higher or lower. A primary source of status in the American culture comes through both one's work assignment and organization.

Several useful points can help plant managers understand the status variable. First, employees wanting high status try to protect that status from outside threat. As a result, any managerial action that is perceived to be lowering one's status will meet resistance. Conversely, managerial action that tends to increase status will be accepted. Since status relates directly to one's self-esteem, and research shows that self-esteem is clearly related to motivational potential, supervisors who act to raise the status of employees increase the motivational potential for each of them.

Since status perceptions differ, it is not always true that managers see actions as affecting one's status the same way that nonmanagers do. A manager changes the work assignment of an employee and moves that employee from one university building to another. That manager may be unable to explain why this particular employee is so resistant to such a change in job assignment. In fact, the manager may feel the new job assignment is actually easier to accomplish than the old one. However, the employee may perceive the new building assignment to be in a lower status part of the institution than the old building assignment. And even though the job duties may be more interesting or easier to perform, these factors may not be enough to offset the perceived lowering of status. Thus, resistance to change, poor performance, and other symptoms of maladjustment may occur.

Threats to status are much more severe if they are visible to one's peers. Management authorities agree that one of the biggest single mistakes a manager can make is to reprimand or insult a subordinate in the presence of others, particularly his or her peers. When one's status is lowered in the eyes of others, the severity of this problem often leads to serious performance deterioration and interpersonal conflict between the superior and the subordinate.

A plant manager who understands the complexities of behavior as dictated by the basic variables outlined above is in a much better position to make the right kinds of management decisions.

6.3 SPECIFIC STEPS IN THE MOTIVATION PROCESS

There is considerable evidence that the motivational levels of American workers have not increased substantially during the past 15 years.[1] In many industries the level of employee motivation has actually declined. Can we reverse this trend and generate greater efficiency from a more productive work force? Yes, but the job is difficult and challenging. In addition to understanding the basic factors already described, five steps will improve employee motivation.[2]

Understanding the Managerial Function

Step one involves understanding the managerial function. What is it that managers do? What differentiates a manager from a nonmanager? In a nutshell, a manager facilitates and a nonmanager implements. Thus, the manager spends time planning, organizing, and providing the support needed so that subordinates can perform assigned tasks effectively. Many managers fall into the trap of either not delegating the implementation process to subordinates, or delegating but continuing to perform the work for the subordinate. Performing the work for subordinates interferes with the overall developmental process and takes valuable time away from the managerial function, which should correctly be planning and facilitation.

Facilities managers on all levels must clearly define for subordinates what needs to be done, the scope of responsibility. Managers must also allocate an equal amount of well-defined authority. The delegated responsibility should then be properly scheduled and monitored to ensure timely performance. This allows growth and development on the part of both the subordinate and superior.

Two principal functions for employees who make the transition from worker to manager are: First, continue to learn about the managerial function and what it means. Management development activities are an important part of this process. Second, understand that a key managerial responsibility involves developing and motivating subordinates within the physical plant department.

The principal function for superiors is to properly and adequately train new managers to help them understand and gain the skills of their new responsibilities. All too often employees promoted into managerial positions want to continue to do previous assignments. They are comfortable with known tasks, and performing them well resulted in a promotion to a position of increased responsibility. Supplementary management training is a useful communication tool to emphasize the difference between the managerial job and nonmanagerial assignments.

In a survey of 282 employees at Texas Instruments Incorporated, M. Scott Meyers found that lack of responsibility was the most detrimental, long-term factor that created dissatisfaction among employees.[3] Physical plant managers should not perform tasks that reduce subordinate responsibility and should be sensitive to cues from subordinates that suggest unwarranted supervisory interference with their work. Also, employees given job assignments should have sufficient authority to carry out those assignments.

When, for example, a carpenter supervisor or utility superintendent, new or old in the job, is a marginal performer, it is usually because he or she lacks knowledge or motivation. Both can be overcome through training. Training done in part by employees' superiors helps employees understand the expectations and perceptions of their managerial jobs and responsibilities.

All too often we use the farm-boy-swimming technique. We throw employees into the pond of management. If they stay afloat and thrash ashore to gain solid footing, they commence to walk. All too often they flounder and go under, especially if we don't teach them the basics of their new challenge *before* we throw them into it.

This training and learning process is continuous for the successful manager. The superior should allow and provide for growth and learning experiences on a regular basis for all management personnel.

Attaining Mutual Agreement on Job Expectations

Once managers understand the managerial function, they can next move to the second step: attaining mutual agreement or understanding of job expectations with subordinates. Two critical factors are involved in this activity. First, the physical plant managers' high-priority items for the subordinate should be perceived, understood, and accepted by the subordinate so their high-priority items match. In the process of reaching an understanding it is not unusual, and is often desirable, to have the boss modify priorities somewhat to bring them in line with the priorities and expectations of subordinates. In other words, this should be a mutual process in which both superior and subordinate make an effective input into the final agreement.

People cannot achieve that which they cannot understand. Perceptions of employees can quickly be determined by asking for their definition of their responsibilities. Then review and compare with the expectations of superiors. After some dialogue a written definition of job expectations results that is acceptable to all parties involved.

It is then important that performance standards be made a part of this agreement. The subordinate should know not only what is expected, but what those expectations mean in terms of accomplishment and how those accomplishments are going to be measured. A good performance standard has three elements: timeliness, quality, and quantity. The performance standard specifies a time period for accomplishment, how much will be accomplished, and how well it should be accomplished. If these three variables are outlined in specifically measureable terms, positive benefits can ensue for both the manager and subordinates. For example, subordinates realize what they are to do and are in an excellent position to perceive how well these things are being done. Managers, on the other hand, are able to evaluate objectively subordinate performance and to defend that evaluation. Since favoritism is detrimental to self-esteem and perceived equity in the work situation, performance standards can help guard against perceptions of favoritism by subordinates and coworkers.

Good performance standards are not always easy to develop. They should be developed by the superior and expressed in a manner that is clearly understood by the subordinate. There is an age-old management game that goes something like this: "I know how I want you to perform. I'm not going to tell you how that is, but I'm going to evaluate your performance on how well you measure up to it." Some call it the mushroom treatment—keep you in the dark, cover you with stuff, then can you.

A subordinate cannot be expected to accomplish anything a superior cannot define and articulate so that both can know when the work is finished or to what degree. It must be measurable. Understanding and commitment to the standard increases with subordinate involvement in this process.

Effective motivation requires the distribution of rewards in accordance with performance. This takes courage, but effective managers examine the system and then determine what rewards are available that can be offered to subordinates for good work. Some managers use salary increases and promotions as rewards, and rightfully so. However, a reward system structured solely in this way usually fails. When individuals perform adequately to receive the salary increase or promotion, the organization doesn't always have the funds or the position to fulfill the reward. Any system is designed to fail if it cannot consistently meet the expectations on which it is based.

Those subordinates who consistently meet or exceed their performance standards are rewarded accordingly, and those who consistently fail to meet their standards are denied equal value. If the standards are set fairly and correctly and the external and environmental influences are considered, such a system promotes effectiveness for the total organization and encourages poor performers to do better and makes good performers feel good about their work records. The courage to differentiate reward allocations on the basis of performance and to defend them strongly is a vital element of effective leadership, an element important in realizing the motivational potential of subordinates.

Understanding Employee Needs

A third basic step in motivating employees is understanding those factors that directly influence employee behavior and response. There is widespread agreement among behavioral scientists that most employees respond to those factors that influence their need satisfaction. Individuals are more or less creatures of their needs, and their behavior reflects that. Managers should not only recognize this fact but try to understand the various need levels of the subordinates who report to them.

Although these needs are complex, several researchers indicate that employees' needs in organizational life tend to cluster around certain categories. Many employee needs can be satisfied through work better than through any other mechanism. These needs are what Abraham Maslow referred to as ego needs.[4] Ego needs include a sense of self-worth, perception of one's status, and a sense of pride and recognition in what has been done. Achievement-oriented people have an abundance of these needs, and they usually seek to satisfy them at work.

Work offers a hierarchy by which one can measure advancement and recognition for superior performance. It offers title and salary, which can be used to measure one's self-esteem at any given time. The facilities organization should have position titles that denote organizational levels, i.e., Director, Superintendent, Supervisor, Employee. Salary should be correlated with but differentiated from with other appropriate determining factors such as nature of work, longevity, and magnitude of responsibility. Uniforms and other visual identification can add to recognition of the hierarchy.

While needs for security, protection, and safety are often handled outside the work setting, satisfaction of egoistic needs generally occurs in the work environment.

Since needs determine behavior, managers who can tie need satisfaction to good work performance have the motivation problem solved. This can be a difficult task. For example, when labor unions are present, protective mechanisms are often established that make it more difficult for managers to differentiate good performers and reward them.

Frederick Herzberg developed one of the most effective approaches to analyzing the impact of specific types of needs on the motivational process.[5] The approach is particularly useful to plant management. Herzberg divided the work environment into two sets of factors. First, factors that lead to employee growth and development, namely recognition, advancement, achievement, etc., which he defined as motivators; and second, the environmental factors such as wages, working conditions, company policy, etc., that maintain the workplace for the employee, he called hygiene factors. Hygiene factors affect job dissatisfaction, so improving hygiene reduces dissatisfaction for employees. In contrast, motivators affect satisfaction, and employee motivation is a function of job satisfaction. Herzberg maintains that job [illegible]on and dissatisfaction are two mutually exclusive factors in a given [illegible]ational environment. Basically, motivation is increased by improving [illegible] application and development of the motivational factors rather than by [illegible] application of the hygiene factors.

[illegible]leges and universities plant personnel exercise their maintenance [illegible]ation profession and skills in an academic environment. It is not unusual for them to be perceived by themselves and others as less important than the faculty or some of the other staff. When members of the campus community including the president, all administrators and staff, and the students acknowledge and recognize their work and contribution, plant personnel become part of the total institution. This valued, inclusive attitude needs to be developed and fostered by plant managers. Managers can build this acceptance by soliciting written acknowledgments, when justified, and by getting appropriate media coverage in the school newspaper and broadcast station, as well as the local community press. Good managers seek out valid recognition for their employees.

Capable employees at all levels grow and achieve if given challenges and not just orders. Those that achieve the best and the most consistently become obvious when given opportunities to perform and succeed at their level of capability. When a deserving employee receives a promotion, everyone in the organization benefits. Everyone is assured that the organization has the potential to benefit each worthy individual.

In studies by Herzberg and associates in the Pittsburgh area over a four-year period during the 1950s, achievement recognition, the job itself, responsibility, and advancement were stated most frequently as those factors that left a good feeling among employees.[6] Keith Davis conducted a study of 36 engineers in a Phoenix electronics firm, and his data generally supported Herzberg's findings. Davis found that the motivational factors of achievement, recognition, advancement, and the work itself frequently generated strong favorable feelings toward the job.[7] A dozen other studies involving 1,685 employees in a variety of occupations found salary to rank only slightly higher as a hygiene factor than as a motivator.[8] Apparently wages can be either a motivator or a hygiene factor, which places them in a unique category.

Specifically, wages can be a useful motivator when they are tied directly to achievement and recognition, one of the strong motivators in the Herzberg model.

The practical message for facilities managers is to have the courage and the skill to relate wages to job performance and then to tie job performance to advancement and recognition. The skillful integration of these three factors can do much to increase the level of motivation in any physical plant setting. Among engineering-oriented employees, achievement is often the most frequently identified motivator. The study by M. Scott Meyers at Texas Instruments found that advancement provided a strong incentive for engineers, and another study by Vincent and Mirakhor found that a statistically significant relationship existed between productivity and job satisfaction among engineers.[9] Since many plant employees are either engineers or engineering oriented, a facilities manager should continually try to increase employee job satisfaction in order to favorably influence motivation.

Managing Wages and Salaries

The proper use of wages and salaries increases managerial effectiveness, and it is the fourth step in the motivation process. Suggestions about the constructive management of the remuneration process follow:

1. The plant director should retain control over some dollar pool for merit increases that are distributed periodically to subordinates for good performance.
2. Facilities managers should communicate to subordinates the criteria that will be used in the distribution of merit increases. Opinions from subordinates in the development of these criteria will aid their acceptance.
3. Effective wage and salary administration is a continuous process. Managers should constantly try to have wage and salary equity in the entire plant organization. Equitable wage and salary conditions have two fundamental characteristics. A direct relationship exists between perceived skill requirements, job difficulty, and pay scales; and good performance is recognized with salary increments.
4. Most employees see wage reductions as seriously threatening their self-esteem and resist any action that reduces pay. Consequently, it is often best to handle overpaid employees through normal attrition and to reduce rates of pay when new employees are moved into these jobs.
5. It is important to remember that the demand for wage increases by employees may be symptomatic of other problems associated with the organizational climate. This is true because wages are tangible, easy to measure, and they are a direct and easy way of

expressing dissatisfaction. Thus, managers should look beyond demands for wage increases by employees to see if there are other more basic causes of the problem.

Choosing an Appropriate Leadership Style

It should now be apparent that there is a considerable amount of information available about the motivation problem, and there are many options available to the practicing plant manager in raising the employee motivation level. Many of these options require courage and strong leadership.

Central to strong leadership is a leadership style fitting the specific managerial situation. Two fundamental choices are available to physical plant leaders with regard to their leadership practices. They can retain tight control over the decision-making process and delegate little authority to those that report to them. Leadership styles that tend to have these characteristics are basically clustered in a group called autocratic. At the other end of the spectrum, these managers can delegate considerable amounts of authority to their subordinates and give them high degrees of autonomy in performing their work. Leadership styles that retain these basic characteristics are referred to as democratic.

Deciding which style is most useful is not easy. Maintaining tight control over employees often raises productivity levels. These increases, however, tend to be short-lived and are attained at the expense of long-term costs, reflected in deteriorating human relationships. Yet, some kinds of problems tend to be particularly suitable for tight-reign control and any other style is clearly inappropriate. While democratic styles produce good human relationships, they usually will only work if employees are knowledgeable of the problem, feel it is important, and strongly support the overall goals of the plant department.

A useful guide to follow in determining how democratic you should be in a situation can be reflected in the number of yes responses to the following specific statements.[10]

- I do not have enough information to make a high-quality decision on my own.
- Acceptance of the decision I make by subordinates is critical to its implementation.
- If I make the decision myself, it is unlikely that it will be accepted by my subordinates.
- Subordinates share in the goals of physical plant management.
- Subordinates have sufficient information to make a high-quality decision or at least to help in this process.

If each of these statements is answered affirmatively, the democratic style is called for. Of course, this has to be coupled with the fact that there is sufficient time to involve subordinates in the decision-making process. Emergency and crisis decisions needing an answer in a short period of time preclude using the democratic approach. Decisions that involve reduction in force, allocation of merit awards, and disciplining employees are among those that normally are handled best on an autocratic basis.

Successful operations exist along the spectrum of management styles. There are three universal elements that have been found to exist in any successfully managed organization:

- The management philosophy is known and understood.
- The leadership style is consistently applied.
- It is flexible enough to meet change and emergencies.

These elements say a great deal about human behavior and what is important. However, given these three principles, the organization that more fully maximizes the potential of its individual members falls on the democratic side of the management spectrum.

The biggest obstacles to adopting a sound democratic approach to management is the natural tendency to want to keep doing those tasks and duties that are particularly interesting, or for those who are promoted into management to want to continue to perform those activities that they did well on their previous job. Good, democratic leadership is based on a willingness to delegate to subordinates those activities that will aid their development and are challenging and interesting to perform. When challenging tasks are delegated, subordinates may have to struggle with these tasks for awhile in order to master them. This is a normal part of the developmental process and should be encouraged within prescribed limits by the facilities manager. When a manager jumps in too quickly to bail out a subordinate struggling with an assigned task, the creative development of that subordinate is stifled, learning is impeded, and the subordinate becomes more dependent as other tasks are assigned. In most instances, these are all negative consequences of helping a subordinate too quickly.

6.4 ORGANIZATIONAL CLIMATE

The key to motivation is found in the characteristics of the organizational climate. Facilities managers should strive to develop a climate that supports democratic leadership, straightforward two-way communication, and is perceived by subordinates to recognize and reward good performance. Employees who do not respond to this type of environment have low achievement needs. These individuals should be identified in the preemployment screening process as not suited for the organization. Physical plant managers who inherit large numbers of these employees from previous administrations should make it clear that this is a new ball game and explain how rewards will be distributed. A few of these employees will probably adjust to the new environment and offer improved levels of motivation. Others will become disgruntled and leave. The unsatisfactory employees that remain may be small in number or placed in positions with minimum negative impact on the rest of the organization.

High levels of performance among employees is usually catching. Poor performers are encouraged to do better by good performers. A good organizational climate moves employees in the direction of solving the motivation problems that confront the plant manager. Also, proper climates attract good employees and put pressure on weaker employees to perform better. Although the managerial task in building a strong climate is a difficult one, once accomplished the rewards are great to both the manager and the employee.

Current population statistics and economic conditions confronting colleges and universities promise even tighter budgetary constraints and increasing pressure to get more from fewer resources. Many physical plant managers will find a deep reservoir of untapped potential among their workers. The application of motivational tools and the use of sound leadership practices can result in substantial improvements in motivation that will release much of the potential in that untapped reservoir.

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CHAPTER 7

Summary

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The staff of any facilities department is the organization's most important asset. The leader of the department must be a competent administrator with excellent people skills. The personnel within the department account for two-thirds of the budget. They are also responsible for consuming at least one-third of the director's available time. The astute plant director recognizes that the proper management of personnel will conserve financial resources as effectively as any energy management system. After all the technical innovations are made, people remain the source of increased productivity, savings, and improved operations.

Physical plant personnel must be part of a well-planned organization. A structure must exist to accomplish the work that fulfills the objectives of the organization and the institution. Clear, concise policies and procedures must exist at all levels within the organization, and each level of the organization must have effective leadership. The combination of a well-planned organization, strong leadership, and highly motivated people is the key to a successful facilities organization.

The director and key support personnel must implement and maintain a thorough public relations program with their campus constituency. Candid communications between the various campus departments is a must for the success of the institution.

Staff recruitment for the plant department must be done on a systematic and well-informed basis. People should be optimally matched to the needs of the job. Federal and state legislation must be complied with at all times in staffing an organization. The numerous Civil Rights Acts, Equal Employment Opportunity legislation, and presidential executive orders are sources of federal requirements. Each state has its unique legislation governing recruitment practices that must also be followed.

Training, or staff development, is an effective management tool when used in a planned, purposeful manner. The plant director must make a commitment to an effective training program if the organization is to be responsive to the needs of the campus community. An effective training program enhances the knowledge, skills, expertise, and attitudes of the facilities department employees. Training must be reviewed constantly and revised as needed to reflect changes in the organization's resources, goals and objectives, organizational climate, and the philosophies of principal administrators. We must commit a portion of our scarce financial resources to our human resources in the form of training.

Facilities managers and supervisory staff must treat their people fairly and consistently regardless of the various labor affiliations. Colleges and universities have established written personnel policies—rules and procedures—that assure consistent and equitable treatment of employees. The director and key staff members must know such guidelines well. Plant personnel that are represented by a labor union have a contract that establishes the standards governing employee and management relations. In addition to knowing the institution's policies, the director and supervisory staff must be well-acquainted with all aspects of the labor contract. Thorough knowledge of the contract is needed to gain optimum performance from the people governed by the contract.

Written personnel policies, rules, and standard operating procedures can be effective management tools. Departmental policies should cover areas not included in any institution-wide personnel policies.

Today's plant administrator cannot be preoccupied with budgets, mortar, HVAC systems, grounds, energy, and deferred maintenance alone. The contemporary facilities manager must include effective management of the organization's human resources as an essential management skill.

PART II

BUDGETING & ACCOUNTING

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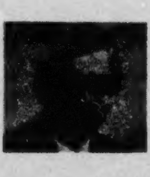
INTRODUCTION

The Plant Administrator's Balance Sheet



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Facilities management has become far more complex in recent years as external and internal circumstances have placed greater demands on the assets of colleges and universities.

Increased costs for energy, general inflation, higher wage rates, government regulations, and similar factors that raise operating costs, coupled with, in some instances, declining enrollments and the increased competition for students have affected the funding that is available for facilities management operations.

This condition has resulted in serious decreases in many facilities department budgets and has affected almost all departments to some degree.

The extent to which a department has been affected is, in most cases, determined by the ability of the department's management to respond to these limitations by preparing and controlling their budget. The preparation, substantiation, distribution, and understanding of the facilities management department's budget is the responsibility of the management of that department.

The facilities managers are, simply stated, responsible for the approval of a budget that is adequate to meet the needs of the plant operations of the institution. Failure to obtain such approval, unless the approval is politically motivated, may rest entirely with the department itself.

Similarly, the ability to live within the bounds of the funding established in the approved budget or to adjust to reduced funding is the responsibility of the department's managers.

The management and control of the budget must be a team effort. It depends on all levels of management within the facilities department to do their part in carrying out sound budgeting and accounting procedures to produce desired results.

Budgeting is a continuous process. Good budgeting procedures go on all year. They encompass all phases of an operation and include all personnel within the organization. The process can be described in three parts: preparation of budgets, implementation of budgets, and budget review and control. The preparation of a department budget requires input from many sources. Managers, supervisors, foremen, accountants, estimators, work control personnel, service staff, consultants, and others can supply supportive data, both historical and projected. It is important to have the "team" participate in the preparation of any budget.

Once a budget has been approved by the funding authority, it must be implemented. That is, it must be put into operational form by the department. Many adjustments may have been made to the original submission. It is conceivable that the budget may not even resemble the original draft. Regardless of the final form, it is up to facilities managers to work out the details, inform staff involved of the changes, and see that the department works within the budget throughout its duration.

It is unlikely that the approved budget can simply be issued within the department and that, without further effort at control, the staff will live within its bounds. Rather, it requires conscious efforts of review and control. Exercising control requires continuous monitoring of costs on a periodic basis. In addition, it requires continuous adjustments as conditions change.

This section will examine preparation, implementation. and control of budgets. In addition, there is a glossary of common financial terms and a business officer's view of budgeting at a state university.

CHAPTER 1

Principles of Good Budgeting

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1.1 BUDGET PREPARATION

Every administrator charged with the management of a department must have a means of measuring the department's expenses against its income. That is vital to maintaining a sound financial base within the organization.

The responsible fiscal manager plans ahead so that funds are available to meet expenses. All anticipated costs are identified and provided for to the maximum extent possible.

The ability of the department to live within its budget may be the single most important measure of performance used by the president or the chief administrative or funding officer in evaluating the overall performance of the department.

While well-maintained buildings and grounds and sound energy programs may be appreciated, they may not receive the overall emphasis of budget accountability in the final evaluation. Therefore, fitting the plant into a perspective of the whole institution is important when dealing with budgets. To put it another way, a college or university does not exist for its facilities. One can argue that it would not exist without the physical plant, but there is a big difference between the two.

All facilities managers should keep in mind that there are many competing interests for the funds that are available. The chief funding office (board of trustees, president, treasurer, or whoever) must make hard decisions with regard to relative funding of departments competing for funds.

After-the-fact complaints about inadequate funds are of no avail. Greater emphasis and care should instead be put into budget preparation and control during the next budget cycle in order to secure adequate funding.

1.2 RELATING TO THE FUNDING AUTHORITY

One key element in successful budgeting may be the personal and professional relationship that exists between the facilities department and the chief funding office.

Take the time to acquaint trustees, the president, treasurer, or business officer with the actual conditions of the buildings and grounds on campus. If they are aware of the deficiencies as well as the good things, they will be more likely to support increased funding.

Share budget concerns with the department personnel. Work hard to build trust and confidence in all the operations and communications that take place between the funding office and department personnel.

1.3 ORGANIZATION OF BUDGETS AND ACCOUNTS

There are a variety of factors that can contribute to well-organized budgets and accounts. Foremost are clarity, substantiation, and up-to-date reporting.

Since the department budget may be viewed by many who may not be familiar with the operation, make sure the budget requests are straightforward and clear in their presentation. Support the budget with facts and data. If the request cannot be substantiated, it does not belong in the budget.

Flexibility comes into play in the budget operation. Be prepared to exercise other options if all requests are not fully authorized or funded. An important strategy to employ is to devise accounting systems that will provide information that will accurately reflect the expenses that have been incurred during the previous budget year.

Strive to maintain and present accurate records. Accurate records will promote increased confidence in the department and help illustrate the department's actual needs.

1.4 BUDGET OBJECTIVES

Budgets consist of expenses related to immediate objectives (such as custodial services, utilities, and routine maintenance) and long-range objectives (such as roof repair programs, long-range painting programs, and carpet installations). Be sure to clearly identify and substantiate both since funds are allocated accordingly. One need may be just as important as the next.

1.5 DATA PROCESSING

Data processing is readily available to most colleges and universities. It should be used in the budget and accounting process whenever possible. Computerized records systems will usually yield increased efficiencies by eliminating manual tasks and providing increased resources in the form of additional, more complete records.

1.6 WORK CONTROL SYSTEM MANAGEMENT

The department's work control system is one of the key elements in good budgeting and good control of approved budgets. It is the heart of any maintenance program which determines where funds are expended. It helps determine the efficiency level of the department and it provides the department with the historical cost data needed for future years. (See Part III: Maintenance Management, Chapter 2, "Maintenance Management Systems", for a discussion of integrated work controls and accounting functions.)

1.7 STAFF PARTICIPATION

It is extremely important that the people who must live with and work within budget limitations have a say in how their budgets are prepared.

Whether the budget is prepared by the director or by the budget office within the department, all levels of management should participate in its preparation. Managers' needs should be sought out and given consideration.

Final budgets should be reviewed and explained to all levels of management.

1.8 THE ACTUAL BUDGET PROCESS

Putting together the budget requires integrating a lot of information. Before figures are even set to paper, a number of items must be considered.

Time Period

Wherever possible, the budget year should coincide with the academic year so that costs and other data relate to the student enrollment and revenue for that year.

Some state institutions must project their budget needs well in advance. The closer the submission date to the actual budget period, the greater the accuracy that can be expected in projected costs.

Expense Categories

It is important to present the budget in a clear and concise manner. Related items of work should be grouped together.

Regardless of the format, there are four main cost elements that must be considered in each of the major account categories.

Personnel Each department should account for all personnel it employs. A job description should exist for each employee. Numbers of personnel in any one category should be determined on the basis of the work that must be performed by that unit during a given period of time. Historical data, work standards, and efficiency studies can be used to substantiate the level of personnel required.

Current and anticipated vacancies should be noted. Known wage increases and/or anticipated wage settlements should be incorporated into the personnel section of each budget category.

Material This category varies from budget section to budget section. Essentially, all of the material purchases that are anticipated for the coming year should be included in this category.

Allowances should be made for increases in building area and numbers of students. Areas where economies have been or can be effected should be noted. Items that have been competitively priced should be identified.

Material can be listed by item, such as paper towels or soap, or by supplier (i.e., Acme Supplies, Inc.), so that known quantities can be identified.

Equipment This category includes both the equipment that is needed to replace worn or defective equipment in buildings and the equipment that is used by the trade or building group in performing their work. Some might argue that the latter properly belongs in a tool account. This will vary from campus to campus depending on the viewpoint of the director of the facilities department and the chief administrative officer.

Once the definition of equipment is established, the budget officer should be consistent in his or her application of the definition.

Contract Services Few departments are staffed to handle all forms of maintenance that are required on a campus each year. As a result, a certain percentage of the repair work must be performed by outside contractors. These services should be identified within the budget as contract services. Where such items are known in advance, competitive bids can be taken. The cost carried in the budget can be based on the price established by the successful bidder.

Whenever possible, competition should be sought for all services that are to be purchased. Purchasing departments and those charged with the responsibility of doing business with outside firms often find it easier to have the work done by one reliable firm. However, problems arise when a contractor assumes that no other company will get a chance to do the work and so fails to continue to price the work competitively.

Surprisingly, considerable monies can be saved throughout the course of the year by making sure that competition is obtained on purchase of all products and services.

Beyond the standard budget categories there are some special cost categories. Security, mail distribution, transportation, construction, and other auxiliary services should be identified separately.

Organized formatting can help promote consistency and clarity. When an institution's budget format will permit it, the APPA classification of accounts for physical plants should be used. (See Chapter 4.)

Budgeting Methods

Many budgeting methods are in use today. Some include zero-base budgeting, formula budgeting, and incremental increases. It is important to select a method of budgeting that is compatible to an institution's budget system.

Supporting Material

It is absolutely essential to have adequate substantiation for all phases of a budget. This is the part of the budget that enables the funding authority to determine whether or not the requested funds are at the proper level.

If the funding authority finds items within the budget that cannot be substantiated, he or she can only assume that the item is not needed. Thus, the item is likely to be deleted.

Objective Format By following the APPA format or by identifying the four items of cost in each budget category, an objective format will be established that will be easily understood by all of the participants in the budget process.

Narrative Descriptions Use written explanations to describe and explain those items within the budget that may be new or otherwise misleading to the funding authority. For example, suppose the facilities manager wished to transfer personnel from the operating engineer's crew to the air conditioning crew. Overall personnel levels will remain the same. However, if the budget authority looked only at the level of personnel in the air conditioning section, he or she would see an increase. A brief narrative description of the action that the facilities manager was taking, inserted at this place in the budget, would explain that current personnel levels were to be maintained.

Photographs Pictures can convey the state of repair of buildings easily and accurately. Do not hesitate to submit photographs as part of the substantiation of a budget request.

Cost Estimates Wherever possible, support budget requests with estimates prepared by the department's estimating staff. This should be done for one very good reason: It is usually more difficult to disapprove an itemized estimate than it is to reduce a simple total allowance figure.

On those items of work that are not going to be performed by in-house personnel, obtain competitive bids that can be inserted in the appropriate section of the budget to substantiate the cost of the work item that is being requested.

Engineering Reports and Studies An engineering report on a proposed project usually lends credibility to the project. It immediately informs the funding authority that the facilities manager had enough concern about this particular project to have it thoroughly studied beforehand. At this stage the funding authority is being approached for the necessary funds to complete the work. The facilities manager is likely to receive full funding for such a project, depending on the priority that he or she and the funding authority can give to the project.

Even if the project is turned down because of lack of sufficient funds, the project is more likely to be funded in future budget years.

Consultant Reports The use of management consultants can be an important tool in the development of the overall plant department operations.

Usually those in higher levels of authority have confidence in a management consultant's report as they recognize it as a professional study. Use consultants to determine the proper work levels for various departmental employees. Obtain their help in the establishment of work control procedures and in the design of other areas of the department's operations.

Having used them, base the department's budget requests on their reports. Include references to their reports and have them available to the funding authority for review if needed.

Historical Cost Data In most budget operations, next year's budget is compared to last year's costs.

As we will see in Chapter 2, which discusses accounting, it is essential to have accurate and meaningful costs available to support and substantiate next year's budget. The more current these historical costs are, the more likely they will be accepted by the funding authority.

Previous personnel costs and levels of purchasing of standard supplies can be easily documented with the use of historical cost data.

1.9 BUDGET MODIFICATIONS

In the late 1960s colleges and universities reached peak enrollments. They received plenty of federal grants for research and other studies and paid for energy at a fraction of today's costs. Budget requests were likely to be approved without hesitation or question. This is not so today.

One can assume with some degree of certainty that facilities managers will be faced with requests to reduce their budgets in order to meet the level of funding available to the total institution.

Blanket Reductions

One of the common practices of many funding authorities is to simply say to each requester "cut X number of dollars out of your budget" or "cut X percent out of your budget." Both of these actions represent blanket reductions to one's budget.

In effect, these reductions leave the final choice up to the facilities manager. However, the initial reduction has been made indiscriminately and without any action on the part of the facilities manager. It is a poor way for any funding authority to conduct business. However, it may be a method with which some facilities managers must live.

Deferred Maintenance

A funding authority may not make a blanket budget reduction, but may instead give instructions to defer all planned roof maintenance, for example. Or again, the funding authority may leave the choice up to the facilities manager after telling him or her to eliminate the funds carried for an ongoing maintenance program. The funding authority may accomplish the same feat in those colleges or universities where maintenance reserve accounts have been established by simply stating that they are going to use these funds for other purposes or reduce them by a certain amount.

This goes under the guise of deferred maintenance. In effect, it is nothing more than "select neglect." In other words, the funding authority has made a decision that the facilities manager must neglect maintenance work that may be critical to the overall upkeep of the facilities.

Fortunately, most budget authorities are now aware of the impact this practice has on their future budgets and they refrain from implementing this practice.

Should it happen, such a directive should not go unchallenged. While one may carry out the instructions like a good manager recognizing one's position on the team, it is important that the facilities manager go on record, in an appropriate way, to inform the funding authority that this kind of action will have serious consequences on the overall upkeep of the institution. A reminder should be issued that this work must be performed at some time in the future and that the work will undoubtedly cost more at that point.

It is much easier for a college or university to continue to set aside a certain portion of its income for these ongoing repairs than it is to raise funds for them in a large-scale campaign.

It is also difficult for the facilities manager to gear up sufficiently to handle large increases in work load when large amounts of funding are suddenly appropriated in order to "catch up" on deferred maintenance.

Selective Reductions

Selective reductions allow the facilities department to determine those items that can be eliminated from the budget. The consequences of such action are clearly stated and made known to the funding authority. The selection of the items is made as the result of a joint effort on the part of the director and the supervisors of the department section involved.

It is a joint effort and, therefore, one that is more readily acceptable to the department personnel.

1.10 SUMMARY

Budget preparation is a principal responsibility of each director of physical plant. The director must work at incorporating sound procedures into the process on an ongoing, year-round basis. The quality of the physical environment of the campus depends on it.

CHAPTER 2

Basic Principles of Cost Accounting

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2.1 INTRODUCTION

Good accounting pays off. Since a part of the budgeting process depends on the records of past department experience, the statistical material that is made available to the budget officer often can make the difference in the level of funding that is granted by the funding authority.

However, accounting for the department's efforts can also serve many other purposes. One prime function is to enable the department to submit appropriate bills for its services to user departments.

2.2 INFORMATION RESOURCES

Maintaining records of current and past expenditures is an efficient guide to budgeting in years ahead. Retaining accurate employee records and charge-back accounts permits a manager to make informed hiring decisions and maintain good rapport with other departments. The preceding are but a few reasons for maintaining good accounting records.

Current Cost Data

At some point, either at the founding of the organization or at the time that new payroll procedures are established, a department must begin to accumulate cost records. They subsequently become historical cost records. These records serve to update the expenditures to date in any fiscal year. When compared with the budget, they offer the manager a guide to the performance of his or her department.

Chronological influences must be considered, however, so that expenditures are put in the proper perspective. Water bills or insurance bills that are only paid twice a year, vacations which are taken during the summer months and thus have an impact on the fringe benefits section of the budget, and other such items must be weighed so that a proper interpretation and comparison of the budget can be made.

It is important to have current cost information available near the end of the fiscal year so that decisions can be made with respect to expenditures that will enable the department to stay within its budget.

Historical Cost Data

Current cost data become historical cost data as time progresses. This year's costs can be used when making decisions about next year's budget requests. They also serve as a basis for comparing the status of this year's budget with last year's budget at any given time.

Employee Records

Employees are always aware of the amount of pay, vacation time, and sick time to which they are entitled. A good accounting system permits these records to be maintained in an orderly manner. The facts should be readily available to the employee.

The cumulative totals of the payroll, vacation time, sick time, holidays, and other fringe benefits, are equally important to the plant manager or budget officer. The records enable these people to make decisions about additional staffing, vacation policy, problem employees, wage increases, and future budget requests.

Charges to User Departments

One other essential resource that a good accounting system provides is the ability to accumulate charges for services rendered to other departments or other cost centers on the campus.

This must be done quickly and accurately. Other departments need to know what their expenditures are in a prompt manner. Thus, there is a need to process invoices from the plant department quickly. These invoices should be accurate if the departments that are billed are to have confidence in the plant department's ability to provide such services for them.

Mistakes can happen, and when they do, they should be recognized immediately. Repeated mistakes can affect a department's credibility with the users it serves. Speed and accuracy are essential in accounting.

2.3 ACCUMULATION OF COSTS

Tracking costs is an important part of the accounting process. Keeping up-to-date cumulative records on where money is being expended, and to what accounts it is billable, is fundamental to the workings of the department. In addition, other information vital to management and employees can be computed and recorded on the payroll processing system.

Payroll Records

The labor time cards that are used by the employees to record the hours worked also can be used to record considerable additional levels of information about the work performed by each employee.

If the payroll system is designed to be used with data processing equipment, the employee's gross pay, the balance of vacation time and accumulated sick time, the overtime, and the other premium pay categories can all be computed and recorded on the payroll sheet. A weekly record of these items can be maintained for each employee on the master payroll sheet. At the end of the year, this information is then readily accessible to the employee or the budget staff.

Material and Equipment Costs

Material and equipment are either purchased from outside vendors or through the internal warehouse or stores section of the department. In either case, invoices are issued for the purchased material. If these invoices are coded with the proper account numbers, their costs can be accumulated in the appropriate cost center against a building or project account number.

Contract Service Costs

Similarly, services of outside contractors are usually obtained by a purchase order with a subsequent invoice rendered by the firm that supplies the service. Usually, these invoices represent only a fraction of the number of invoices for material and equipment purchases. They can easily be recorded manually unless data processing is available for recording the department's material and equipment costs. If so, contract service costs should also be kept on that system.

2.4 BILLINGS

Most of the cost information that is maintained and accumulated is done for the purpose of providing the department with a means for distributing its costs to the proper account.

Account Number

The key to this process is to establish a system of account numbers that can be easily understood by both the personnel within the department and the cost centers where these costs are channeled.

This account number enables employees to charge the time for their services to the proper account. Likewise, it enables the department to accumulate these costs in that account so that at any given period of time, usually monthly, these costs and charges can be billed to the proper party.

It is essential that the account number appear on the work order that is issued for the work so that the employees performing the task receive and record the number automatically.

Surcharge or Burden

There are many costs associated with a simple task in addition to the employee's basic wage rate. These costs, which generally can be defined as fringe benefits and indirect costs, must be added to the employee's hourly wage rate if the invoices for the employee's services are to be an accurate reflection of the cost of performing the requested task.

These costs are generally known as a surcharge or burden to the basic hourly rate. They may vary in percentage from 5 percent to 50 percent or more depending on the items that are included.

Fringe Benefits In addition to the employee's basic wage rate, one must allow for vacation time, sick time, holidays, jury duty, premium pay (special premiums the employee receives for performing certain tasks, but not including overtime), and any other benefits that are charged to the department for each employee.

These costs, computed on a yearly basis, can be compared to the cost of the employee's productive time and a percentage can be established. This percentage is added to the employee's hourly base rate to reflect his or her productive hourly cost.

Indirect Costs In addition to employees' benefits, cost of planners, estimators, schedulers, purchasing agents, stock clerks, truck drivers, telephone costs, transportation costs, and foremen's time spent in nonproductive work can all be included in the indirect costs.

These costs can be accumulated and compared to the total labor expended for these operations. A percentage can be established that can also be added to the percentage for the fringe benefits surcharge. The combination of these two percentages establishes the burden or surcharge that should be affixed to all payroll costs.

Rather than show this as a percentage added on at the end of the invoice, it is desirable to add this markup to the individual's hourly rate to establish a billing rate for each employee.

2.5 REPORTS

Costs can be accumulated into various groupings depending on the plant manager's needs for historical cost data. The following are suggested as the minimum reports that should be obtained.

Building Service Cost Records

A record should be kept of all expenses for services rendered on each building on campus. This report enables the plant manager to see whether there is a disproportionate amount of funds being expended on a particular building as compared to other buildings.

Task Costs

Costs should be accumulated for the various task categories (i.e., hardware repairs, painting ceilings, painting interior walls, etc.) for the different groups within the department. Supervisory personnel within the department then can determine which tasks consume the greatest amount of time throughout the course of the year.

If these tasks are related to the various buildings where they are performed, the supervisor can make a judgment as to whether or not these costs are disproportionate to the work involved.

Project Cost Records

It is important to accumulate a record of costs associated with each project. For example, if an office is to be renovated for a department, an account should be established for all costs related to that project. Each of the trades working on that project should charge their costs to that account number. In this manner, charges can be billed either on a periodic basis or accumulated until the end of the project.

This project cost information also becomes a valuable tool, permitting the estimating department to compare their estimates with the actual costs incurred.

Material and Equipment Purchases

It is necessary to accumulate the cost of material and equipment purchases in the proper accounts for the same reason stated above. As noted previously, this can either be done with data processing equipment or manually.

Benefit Records

Payroll records, vacation time, sick time, jury duty time, overtime, and any premium pay should be accumulated on the personnel payroll record.

2.6 CONCLUSION

Each department must develop a means of maintaining accurate accounting records of basic items of expense. Managers can expand and elaborate on these reports as their needs develop.

CHAPTER 3

Budget Control Procedures

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3.1 INTRODUCTION

If plant department personnel are to adequately control their expenditures throughout the budget year, they must employ sound management techniques once they receive the approved budget.

The battle to be waged against overspending is a fierce one, but there are tools and techniques available to achieve control of the budget. They include measures such as using "prioritized" budgets, maintaining timely accounting records, exerting firm control over purchasing, and building in contingency funds. This chapter illuminates some methods that can help plant administrators achieve one of their more difficult tasks—operating effectively while living within their financially prescribed, and sometimes pressed, limits.

3.2 IMPOSITION OF SPENDING LIMITS

Keeping the lid on cost overruns is not easy. One of the foremost tools in combatting overspending is to establish a firm rule that expenditures must not exceed available funds. Basic as it may seem, and difficult as it may be to abide by, such a restriction may be imposed by the chief funding authority of an institution in order to control expenditures. To live within available funds, the budget officer must construct a conservative budget, creating a reserve to fund projects as the budget year progresses.

The basic budget should be referred to as the "A" or primary budget. It should include funding for only the essential activities. Expenditures for additional programs and activities are grouped into "B" or secondary, and "C" or future, budget requests.

If additional funds become available during the year, activities from the secondary group are released in order of priority until the available funding is expended. Additional funding may depend on a rise in projected enrollment, fund-raising campaigns, or budget reduction policies that produce surplus funds.

This form of budgeting should be carried out in conjunction with the department's long-range plan for the future. Otherwise, long-range objectives may never be attained since they never reach the stage of becoming part of the primary or secondary budgets.

3.3 DIVISION CONTROL POLICY

A policy can be established that clearly places the responsibility for budget control on the person in charge of a section of the department. The grounds foreman, for example, should be responsible for the personnel, material, equipment, and contract maintenance in his or her unit or section.

This procedure should be tied in with reporting techniques that allow top management to review each section's performance on a regularly scheduled basis. All committed funds, including all open purchase orders, should be reported.

3.4 TIMELY ACCOUNTING PROCEDURES

In order to compile the accurate reports recommended in Chapter 2, it is essential that the purchasing department and the controller's office develop an efficient system for issuing purchase orders and recording expenditures.

Prompt recording and payment of all invoices help to improve the accuracy of cost reports.

3.5 PURCHASING CONTROL

One cost-control strategy managers can employ is to limit the approval and authorization of expenditures within the department. It is important to establish levels of spending authority that match responsibilities. The approval of major expenditures for contracted labor or capital expenditures should be the responsibility of the department head.

3.6 ESTABLISHMENT OF PURCHASE CUTOFF DATES

Establishing cutoff dates for buying goods is another method that helps keep financial outlays in check. Purchasing must be done on a regular basis to keep the plant running smoothly, but following some common-sense rules helps to promote orderly and well-monitored spending. Described below is one useful budget control technique.

Managers should assume that all items that are vital should have been ordered prior to 30 to 90 days before the end of the fiscal year. Set a cutoff date for this point in the fiscal year. Establish the cutoff date well in advance so that all staff are aware of the policy. Any purchase required after the cutoff date can then be ordered only with the special approval of the budget officer or department head. Some exceptions would apply, of course, in the area of utilities and ongoing maintenance.

3.7 COMMUNICATIONS STRATEGIES

One of the better ways to keep good control of a budget is to maintain good rapport with the people who are closely related to it. It is consequently important to communicate with members of the department charged with budget responsibilities. Make them aware of budget goals and objectives. Let them share in the establishment of those goals.

All department members should understand that the budget is being used as a tool to determine salary increments, measure progress, and determine the efficiency of the units within the department.

3.8 BUDGET AMENDMENT

Almost all budgets are affected by changes in the operating plans that take place during the year. Adjustments should be made to the budget in order to reflect the changes and create confidence in the management process. A budget can be amended through the use of a contingency fund built into the budget for that purpose or it can be amended by line-item transfers.

Price increases, declining enrollment, limited fundraising, and emergency breakdowns are all examples of items that could precipitate a budget change. It should be the responsibility of the department head or a manager at that level to approve such amendments.

3.9 LINE-ITEM TRANSFERS

Funds can be transferred from one account to the other to reflect changes in the status of the affected accounts.

The facilities manager must decide if line-item transfers can be made within sections of the department. Otherwise, such transfers must have his or her approval.

3.10 COST MONITORING

To control budgets firmly, it is essential to continue to monitor costs on a regularly scheduled basis. Data processing is a tremendous asset in accomplishing this task.

Some examples are presented below of reports that can be prepared by data processing, provided the work control procedures are designed properly:

- Payroll (personnel).
- Accumulated vacation, sick leave, and other benefits.
- Individual trade costs by activity.
- Individual project costs.
- Individual building charges.
- Material and equipment expenditures.
- Costs charged to others.

3.11 BUDGET REDUCTION PLANNING

If it becomes necessary to reduce the budget because of limitations placed on the department by the funding authority, the facilities manager will be faced with difficult decisions. To rise to the challenge, the manager should invoke the process of reduction planning rather than make arbitrary or across-the-board cuts.

Under the planned process, the manager and other members of the team review all alternatives and rank them in order of priority. Cuts are thus made in order of importance and reflect the thinking of other department members and not just the manager.

Any action should be a deliberate attempt to eliminate items that will have the least impact on the operations of the department.

CHAPTER 4

Classification of Accounts for Physical Plant

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4.1 INTRODUCTION

The Association of Physical Plant Administrators (APPA) and the National Association of College and University Business Officers (NACUBO) jointly developed a classification of accounts in order to standardize budget categories.[1]

This standardization facilitates comparisons of costs and numbers of employees assigned to specific tasks in colleges and universities throughout the United States.

Where possible, it should be used by plant departments as a basis for their budget format.

4.2 MAJOR ACCOUNTS

Major accounts are to be broken into various standardized categories. They are:

- Section 1—Physical plant administration.
- Section 2—Building and equipment maintenance.
- Section 3—Custodial services.
- Section 4—Utilities.
- Section 5—Landscape and grounds maintenance.
- Section 6—Major repairs and renovations.
- Section 7—Other services.

4.3 COSTS INCLUDED UNDER MAJOR ACCOUNTS

For each major account certain costs are recorded. An outline of expenditures by major account is shown.

Section 1: Physical Plant Administration

All activities necessary to carry out the duties of management and administration for all areas under the jurisdiction of the plant department are included. Examples of the activities are:

1.1 Administration. Salaries, wages, employee benefits, travel, equipment, and other operating costs required for administrator; assistant administrators; office personnel, including those assigned to payroll, billing, materials, ordering, personnel records, and dispatching of work orders for the plant department. Other administrative operating costs included are supplies, materials, pro rata share of telephones, postage, computer rental, accounting costs, and career training programs.

1.2 Engineering. Salaries, wages, employee benefits, travel, equipment, and other costs required to provide technical and engineering services necessary to effectively carry out functions *assigned* and *funded* in the plant department. This includes staff personnel such as engineers, architects, draftsmen, estimators, schedulers; preparation of documents for contractual maintenance and renovations; analysis of systems and modes of operation, plant records etc. Preparation of architectural and engineering plans and specifications for alterations and new construction normally are funded from other sources.

Section 2: Building and Equipment Maintenance

Building maintenance includes all items related to routine repair of buildings, structures, and appurtenances, including normally recurring repairs and preventive maintenance. The following are included:

2.1 Interior and exterior of buildings.
    2.1.1 Plumbing, heating, air conditioning, and ventilation.
    2.1.2 Electrical repairs of all types including primary and secondary systems, certain lamp replacements (requiring special ladders and rigging), and maintenance of outdoor lighting fixtures (excluding energy costs).
    2.1.3 Carpentry and cabinetmaking.
    2.1.4 Painting and glazing.
    2.1.5 Hardware, locks, keys, closers, and records for same.
    2.1.6 Roofing and sheet metal work, including downspouts and gutters.
    2.1.7 Welding and necessary machine work.
    2.1.8 Elevators and similar equipment.
    2.1.9 Miscellaneous building repairs such as tuckpointing.

2.2 General-purpose classroom furniture and equipment within buildings, but not inventoried to a department.
2.3 Utility distribution systems inside buildings—electrical, heating, process steam, water lines, gas lines, and sewer lines (storm and sanitary).
2.4 Operating and replacement costs of all equipment, materials, and tools used in building maintenance, excluding hand tools furnished by employees.

Building maintenance also may provide services on a reimbursable basis to other accounts. Examples of these are auxiliary enterprises, alterations and improvements, new construction, experimental and special teaching support facilities, and departmental inventoried equipment.

Section 3: Custodial Services

All costs related to custodial services in building interiors are included, except those for auxiliary enterprises and hospitals. Specific costs are—

3.1 Salaries, wages, and employee benefits of custodians; supervision; and services required for cleaning building interiors.
3.2 Small setups only where materials for special setups are stored or kept within the same building.
3.3 Snow removal on building steps plus five feet (or similar predetermined length) of sidewalk in each direction.
3.4 Other operating costs such as paper, paper towels and tissue, wax, erasers, chalk, cleaners, and other materials and supplies.
3.5 Operating and replacement costs of all equipment used in connection with custodial services and lamp replacement where lamps are readily accessible without special ladders and rigging.
3.6 Elevator operation on nonautomatic equipment.

Common operations include mopping, sweeping, and waxing floors (sanding and refinishing floors are excluded); dusting, polishing furniture and fixtures such as venetian blinds, partitions, pictures, maps, and radiators; cleaning chalkboards, chalk trays, erasers, and replacing chalk; washing and dusting walls; cleaning and disinfecting commodes and urinals; cleaning and washing other fixtures, walls, and partitions, and replenishing supplies for restrooms; emptying and cleaning waste receptacles; dusting and cleaning windows and other glass surfaces; sweeping and cleaning entrances; and opening and/or closing building doors and windows.

Generally, services requiring technical direction at the time of performance, such as cleaning chemistry laboratory bench tops, decontaminating radioactive facilities, or cleaning extremely delicate apparatus, are not classified as custodial, but usually are provided by the department having specific jurisdiction.

Section 4: Utilities

All energy costs for heating, cooling, light and power, gas, water, and other utilities necessary for physical plant operation are included. These normally are—

4.1 Payroll costs of all supervisory and operating personnel in connection with utilities.
4.2 Operation and maintenance of heating and power plant equipment, including water plant and sewage disposal plants.
4.3 Operation and maintenance of equipment in central air conditioning plant.
4.4 Contractual costs for purchase of electricity, water, and sewage treatment.
4.5 Operation and replacement costs of all equipment used in connection with production of utilities.
4.6 Maintenance of utility tunnels, outdoor distribution systems for electricity, gas, steam, compressed air, chilled water, high-temperature water, domestic water, and sanitary and storm drains. This expense *does not* include open-ditch drainage.

Section 5: Landscape and Grounds Maintenance

Grounds maintenance includes operation and maintenance of campus landscape and grounds. Excluded are areas not intensively maintained by the plant budget and/or other areas for which the plant department is reimbursed. Specific costs are—

5.1 Salaries, wages, and employee benefits of all supervisory and operating personnel in connection with grounds.
5.2 Maintenance of all areas of the main campus; growing things such as trees, grass, shrubs, and flowers; nursery stock including seeds, fertilizers, and plant materials.
5.3 Maintenance of roads and walks, parking areas, irrigation systems, signs, and other landscape features.
5.4 Snow removal.
5.5 Maintenance of golf course, athletic practice fields, and stadium and varsity fields unless operated as auxiliary enterprises.
5.6 Maintenance of physical education, intramural, and ROTC drill fields.
5.7 Maintenance of open-ditch drainage, fences, retaining walls, and riprap.
5.8 Care of miscellaneous fixed equipment such as benches and shelter houses.
5.9 Operation and replacement costs of all equipment used in connection with grounds maintenance.

Section 6: Major Repairs and Renovations (Special Line Items)

All costs for major nonrecurring repairs and major deferred maintenance items are included. Major projects are those costing in excess of $10,000 or a similar amount as determined by the institution. Costs that fall in this category are—

6.1 Cost of salaries of supervisory and operating personnel connected with major repair and renovation projects.
6.2 Line-item special allotments and essentially large improvement items.
6.3 Replacement costs of all equipment used in connection with major repairs and renovations.
6.4 Costs related to planning, design, or administration of major repairs and renovations.

Section 7: Other Services

Other essential services not consistently within the plant department, yet frequently assigned, are—

- Automotive repair.
- Bus systems.
- Construction planning and inspection.
- Communications (telephone and telegraph).
- Fire protection.
- Mail and messenger service.
- Property insurance.
- Purchasing and stores.
- Safety.
- Security.
- Solid waste disposal.
- Traffic.
- Trucking and moving.

4.4 DEFINITIVE TERMS

Several terms that relate to accounts for the plant department require definition and fuller explanation. They are presented below.

Gross Area

The area reported is the total area maintained by the department and for which the department has a budget. Any area for which the department is reimbursed should not be included. Areas and costs should be included only if the plant department is responsible for them. Gross area is determined in accordance with the following guidelines from Publication 1235 of the National Academy of

Sciences, National Research Council ("Classification of Building Areas," Federal Construction Council Technical Report No. 50). In the event gross area already is calculated on some other basis, report it as such, but indicate by footnote the basis or reference for calculation.

Definition Gross area is construed to mean the sum of floor areas included within the outside faces of exterior walls for all stories, or areas, having floor surfaces.

Basis for Measurement Gross area should be computed by measuring from the outside face of exterior walls, disregarding such extensions as cornices, pilasters, and buttresses.

Description In addition to ground-to-top-story internal floored spaces covered in the definition of gross area above, gross area should include basements (except unexcavated portions), attics, garages, enclosed porches, penthouses and mechanical equipment floors, lobbies, mezzanines, functional balconies—inside or outside—and corridors, provided they are within the outside face lines of the building. Roofed loading or shipping platforms should be included whether within or outside the exterior face lines of the building.

Limitations Open courts and light wells, or portions of upper floors eliminated by rooms or lobbies rising above single-floor ceiling height, should not be included in the gross area, nor should unenclosed roofed-over areas or floored surfaces with less than six feet, six inches clear headroom be included unless they can be designated and used as either net assignable, mechanical, circulation, or custodial areas.

Part-Year Occupancy When new buildings become operative during a year, or if an existing building is in service for only part of a year, the area reported is the gross area multiplied by the fraction of the year the building was in service. Example: The fiscal year ends June 30. A new building of 100,000 gross square feet is accepted for beneficial occupancy April 1. The area reported is $\frac{3}{12}$ × 100,000 square feet, or 25,000 square feet for the year of first occupancy. The following year, the area reported is 100,000 square feet.

Student Enrollment

Fall enrollment data should be reported consistently from one year to another. If a change in reporting procedure or in calculation of full-time equivalent students is made, such change should be clearly documented to eliminate any misunderstanding or confusion by users of the data.

END NOTE

1. This article was adapted from an article published by the National Association of College and University Business Officers. "A Classification of Accounts for Physical Plant," *College and University Business Administration: Administrative Service—A Supplement* (Washington, D.C., June 1975): 1-5.

CHAPTER 5

Formula Budgeting as a Technique

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The decline in college and university maintenance budgets during the 1970s and the concurrent growth in maintenance deficits became a matter of national concern. The problem of deferred maintenance has frequently been discussed in alarming terms. There are fears that many buildings less than 20 years old are becoming obsolete far before their expected useful life has elapsed. There even have been concerns expressed that deferred maintenance may be unnecessarily endangering life and limb or that the very survival of some institutions may hang in the balance.

The maintenance issue must be attacked on two fronts simultaneously. The maintenance deficit (deferred maintenance) must be eliminated and, at the same time, annual maintenance budgets must be increased to adequate levels in order to eliminate the increase in the maintenance deficit.

A number of states (Texas, Florida, Colorado, Washington, Oklahoma, to name a few) employ budget formulas that are intended to provide adequate and equitable annual budgets for routine maintenance functions rather than rely on more traditional methods of subjective budgeting.

The reasons for resorting to budget formulas are many. Among those frequently cited are that formulas—

- Inject objectivity into the budget process by using quantified data.
- Tend to improve the equitability of treatment of comparable institutions.
- Are intended to provide adequate but economical budgets.
- Are an efficient means of budgeting comparable budget units permitting greater attention to be paid to noncomparable budget elements.

This chapter is adapted from an APPA publication entitled *Formula Budgeting: An Approach to Facilities Funding* by David L. McClintock. For a fuller treatment of the topic of formula budgeting and how it can be applied to facilities management, see this monograph.

At the most basic level, the formula budget can provide something on which requestor and appropriator alike can agree. A formula might be considered a useful one if it is simple, flexible, sensitive to changing conditions, based on reasonable and adequate data, and does the job intended of it.

While the figures presented are based on standards formulated in the 1970s and doubtless have been adapted to meet current institutional climates, they serve to guide the facilities manager in an objective approach to budgeting.

5.1 EARLY EFFORTS AT FORMULA BUDGETING

Walter W. Kraft, writing in the May 1950 issue of *College and University Business*, was one of the first to argue for formula budgeting. As described by Kraft, the formula method provided resources only to the building maintenance function, which was defined then essentially as it is now, in the APPA recommended chart of accounts. Kraft observed that the uncertainty of prices for labor and material and a high construction level emphasized the necessity of setting up a workable, easily understood method of preparing a maintenance budget for the physical plant. He went on to point out that in many instances buildings had been permitted to deteriorate to the point where the repair item became a remodeling item. This places a great burden on a maintenance budget, is wasteful, and may encroach upon the instructional budget. Finally, he noted that many building repairs were made in a more or less temporary manner, which contributed to a more rapid deterioration of the building. Often money is allocated for building maintenance only after all other money requests have been met.

Kraft briefly described alternative formulas for budgeting building maintenance. He dismissed methods based on gross square feet of building area or on cubic feet of building volume because of the wide variety of building types in use. He argued that the cost of maintenance will vary markedly over time and among building types so that neither area nor volume formulas could adequately take those differences into account.

Kraft went on to develop a formula for the building maintenance budget which, in its most basic configuration, may be written as follows:

$$\text{Maintenance Budget} = \text{Maintenance Cost Factor} \times \text{Current Replacement Cost of the Building(s)}$$

Kraft identified three construction types, each with its own Maintenance Cost Factor, that are shown in Figure 5-1.

The formula says that the annual maintenance budget for a building should be a percentage of the current replacement cost of the building. The formula has the advantages of being relatively simple; of being broadly applicable to a variety of institutions; of incorporating an allowance for

Figure 5-1

Kraft Formula Method: Building Construction Types

Construction Classification	Factor
Wood-frame construction	1.75%
Masonry-wood construction	1.30%
Masonry-concrete or masonry-steel with concrete floors	1.10%

inflation automatically; and of being soundly based in easily auditable variables routinely dealt with by the facilities department.

It has the disadvantages of requiring original construction or acquisition cost data which may not be readily available; of not providing guidance about staffing levels; and of applying only to a part of the total physical plant function.

5.2 THE TEXAS APPROACH

In Texas, statewide formulas were devised for a number of institutional budgets at the direction of the Texas State Legislature in order to promote "a reasonable level of financing with an equitable distribution of funds among the institutions." The Texas budget formulas were intended to be scrutinized frequently and revised as experience dictated. The study committee dedicated itself to the following approach:

- "Make a thorough study of physical plant operations at the 18 Texas schools.
- Analyze these various operations.
- Develop definitions for each group operation.
- Determine those operations which might be adaptable to a formula approach.
- Develop criteria for base formulas for those operations.
- Test the results of the formulas recommended.
- Support and justify the facts and findings recommended by the committee."

The committee identified five physical plant budget subdivisions for study: building maintenance; custodial services; grounds maintenance; utilities; and administration, planning, and general services. In the end, the committee developed dollar formulas only for building maintenance and for custodial services. No common formula for utilities was thought possible and no basis for an administration formula was found. Data were insufficient to develop a definitive proposal for a grounds formula although the general form for one was suggested for further study.

Building Maintenance

The cost of maintaining a building will vary from year to year. Large expenditures for painting, reroofing, and the like are done only infrequently. Costs also vary with intensity of use by building occupants and according to the standard of maintenance adopted by the institution. Over a period of 15 to 20 years, the average costs might be expected to approximate a uniform maintenance cost factor for a given type of construction.

The decision was to base the building maintenance formula on the current replacement cost of the building as recommended by Kraft in 1950. Kraft's construction classification and maintenance cost factor system was adopted as published except that each of the cost factors was to be increased by 0.15 percent for air conditioned buildings to reflect the higher cost of maintaining the added mechanical equipment.

Current replacement cost for a building was to be computed by multiplying the original building cost by a factor taken from a construction cost index chart. The formula was found to produce realistic and equitable building maintenance budgets for all 18 institutions. The formula was not presumed to provide for supervisory costs, other than foremen, nor was it presumed to provide for deferred maintenance and major rehabilitation projects. The formula may be stated concisely as:

1. Current building replacement cost = Original building construction cost × Construction Cost Index
2. Annual maintenance budget = Current building replacement cost × Maintenance Cost Factor

Custodial Services

The study committee concluded that the custodial services budget should logically be derived from the measure of gross square feet of building space served by custodians. A number of institutions were surveyed and the results showed that the average number of gross square feet of space assigned each custodian ranged from a low of 5,000 to a high of 35,000 with two-thirds of the 90 respondents falling within a range of 11,000 to 25,000 gross square feet per custodian. The range among the 18 Texas institutions was found to be 14,000 to 20,000. The committee recommended adoption of 14,000 as a Texas standard.

After analyzing prevailing salaries paid custodians and after assuming wages-to-supplies ratio of 10 to 1, the custodial budget formula was finally educed to one of 19¢ per gross square foot. Budgets were prepared on this asis for a year or two and, subsequently, it was found necessary to increase he formula budget to 23¢ per gross square foot. The formula may be stated oncisely as:

$$1.\ \text{Number of Custodial FTEs} = \frac{\text{Number of gross square feet maintained}}{14{,}000}$$

$$2.\ \text{Custodial Salary Budget} = \text{Number of Custodial FTEs} \times \text{Average Custodial Salary}$$

$$3.\ \text{Custodial Supplies Budget} = \text{Custodial Salary Budget} \times 10\%$$

The two budget components may be summed and reduced to a per-square-foot measure, if desired.

Grounds Maintenance

The study committee proposed a grounds maintenance budget formula that factored in a lawn acreage component plus a student/staff pedestrian usage component. What was later adopted as a grounds maintenance formula uses three factors: percentage of linear feet of perimeter of all campus buildings, acreage maintenance unit, and a pedestrian usage component. That total is then multiplied by a salary inflation factor derived from a U.S. Department of Commerce statistic.

Evaluation

The Texas budget formulas were evaluated after several years of use. In general, in spite of the formula approach, the proportion of physical plant costs in total institutional appropriations continued to decline. Put another way, other sectors of the institutional budget grew faster than the physical plant budget.

These conclusions were reached:

- The distribution of physical plant costs by type (custodial, grounds, etc.) shows a definite pattern.
- There is a reasonably high correlation between physical plant appropriations and FTE student enrollments.
- There is almost a perfect correlation between physical plant budgets and gross square feet of building space.

- There is a very low correlation between per-square-foot (or per-FTE-student) physical plant budgets and the absolute size of institutions which tends to argue against the premise that the larger, more complex, institutions automatically need more funds per unit of output than do the smaller ones.
- Physical plant appropriations per-square-foot are inversely proportionate to the size of the institution.

The latter conclusion implies that the small college must devote a larger share of its budget to functions such as general administration and general expense than does a larger college or university. Certain basic physical plant services must be provided regardless of the size of the enrollment and these services do not normally increase beyond the basic level in proportion to increases in enrollment.

One may summarize these basic conclusions as follows:

- The larger the FTE enrollment, the larger will be the physical plant budget.
- The larger the number of gross square feet of space maintained, the larger will be the physical plant budget.
- The smaller school will typically have a higher physical plant budget per gross square foot than will the larger school.

One may almost state with certainty that these basic conclusions are universally true.

5.3 THE FLORIDA APPROACH

In developing a formula approach to physical plant budgets for the state universities in Florida, the Interinstitutional Physical Plant Committee of the State University System of Florida planned to study ways of achieving greater uniformity among institutions with the hope of improving equity among institutions.

The committee identified four budget methods to investigate: present budget level plus justified increases, percentage of some other budget, workload standards approach, and unit of size approach. The committee suggested that the approach of the future might well be some form of input-output analysis that would relate physical plant and other budgets to institutional output.

The committee concluded that "the present level plus justified increases" approach was unacceptable because it perpetuated existing budgetary inequities and depended on salesmanship abilities rather than on actual needs. They argued further that the approach bears no relationship to the job to be done and gives no budget guidance to new institutions.

The "percentage of some other budget" approach was also rejected because its relationship to the physical plant functions was entirely too tenuous to be viable and too susceptible to arbitrary modification.

The committee did give serious consideration to the "workload standards" approach but rejected it in the end because it is extremely difficult to inventory and to quantify all work elements, difficult to compare with other institutions, and is open to argument.

The "unit of size" approach was selected.

The committee identified seven criteria for the final budget formulas to meet:

- The input data must be readily obtained and readily verified.
- The data must bear an acceptable relationship to the function to which they relate.
- The data should lend themselves to comparison with other institutions, external to the state university system, if at all possible.
- Because the ultimate formulas must be examined and accepted by lay persons, a complex subject must be reduced to a simple solution.
- The results must satisfy the needs of seven institutions ranging from those still in the planning stages to those with enrollments of 20,000 or more students.
- The results should provide a basis for physical plant budgeting for new and emerging institutions.
- The results should establish staffing which, in turn, would determine salary monies required.

The committee developed five physical plant budget models.

Custodial Services

The custodial services formula is based gross square feet of space served by physical plant staff. The basic formula provides for custodial staffing as follows:

- 1 custodial service superintendent.
- 1 custodian FTE for every 12,000 gross square feet of space.
- 1 custodial supervisor for every 15 custodial FTE.
- 1 assistant superintendent for every 4 custodial supervisors.

Salary monies were determined by salary levels of the state personnel system. The model also allowed a custodial service expense allowance of $0.04 per gross square foot.

Administration and General Services

The administration model is based upon the gross square feet of state-supported buildings served by the physical plant department. The minimum formula administration staffing includes:

- 1 department director.
- 1 assistant director.
- 1 draftsperson.
- 2 secretaries.
- 1 accounting clerk.
- 1 clerk-typist.

The following additional staff are added to the basic complement:

- 1 assistant director at 2,000,000 gross square feet.
- 1 assistant director at 4,000,000 gross square feet.
- 1 engineer at 500,000 gross square feet.
- 1 engineer for each additional 750,000 gross square feet.
- 1 draftsperson at 1,000,000 gross square feet.
- 1 additional draftsperson for each additional 1,000,000 gross square feet.
- 1 additional FTE position for each 500,000 gross square feet.

Salary monies are determined by the state personnel system. The model also allows an administration expense budget of $0.01 per gross square foot.

Grounds Maintenance

The grounds maintenance model is based upon the gross area of all campus buildings including both state and non-state funded facilities. The basic grounds maintenance complement includes:

- 1 grounds maintenance superintendent.
- 14 FTE groundskeepers.

For institutions having more than 500,000 total gross square feet of space, add:

- 1 FTE groundskeeper for each 45,000 gross square feet.
- 1 groundskeeping supervisor for each 15 FTE groundskeepers.
- 1 assistant superintendent for each 5 supervisors.

Salary monies are determined by the state personnel system. The model also allowed a supplies budget of from $0.025 to $0.055 per gross square foot depending upon factors such as climate or soil conditions.

Campus Security

The security model is also based upon the gross area of all campus buildings including both state and non-state funded facilities. The basic security force is as follows for institutions up to 800,000 gross square feet of space:

- 1 superintendent.
- 10 FTE security officers of various ranks.

As the institution grows, additional positions are added. See Figure 5-2.

Figure 5-2

Florida Campus Security Model

Size Range	Additional FTE
800,001 to 1,000,000 GSF	Add 1 FTE per 80,000 GSF
1,000,001 to 2,000,000 GSF	Add 1 FTE per 90,000 GSF
2,000,001 to 3,000,000 GSF	Add 1 FTE per 100,000 GSF
3,000,001 to 4,000,000 GSF	Add 1 FTE per 110,000 GSF
4,000,001 to 5,000,000 GSF	Add 1 FTE per 120,000 GSF
5,000,001 to 6,000,000 GSF	Add 1 FTE per 130,000 GSF
6,000,001 to 7,000,000 GSF	Add 1 FTE per 140,000 GSF
7,000,001 and up GSF	Add 1 FTE per 150,000 GSF

Salary monies are determined by the state personnel system. The model also allows an expense budget of $0.006 per gross square foot.

Building Maintenance

Florida adopted exactly the same building replacement cost approach to building maintenance budgeting used in Texas. The Florida formulas implicitly recognize that relatively larger physical plant staffs are required by the smaller institutions and that economies of scale are obtained at the larger ones. The Florida formulas have the advantage of giving specific guidance about staffing patterns and organization in four areas of physical plant responsibility.

5.4 THE STATE OF WASHINGTON APPROACH

The formula budget approach was initiated by the presidents of the six four-year institutions in Washington State in order to "facilitate the analysis and comparison of the plant operation and maintenance programs at the six colleges and universities." Seven major functions were included in the definition of plant operations:

- Building maintenance.
- Custodial services.
- Grounds maintenance.
- Utilities.
- Administration.
- Police, fire, and safety.
- Refuse disposal and trucking.

Formulas were developed for the first four functions listed.

The committee defended the use of formulas on three grounds. "First, each formula is designed to apply reasonable standards to each function or activity. Second, the use of formulae enables each institution to determine its relative position with respect to each formula item and to adjust its allocation of funds accordingly. Third, the formulae make it possible to compare operating budget allocations for plant operations and maintenance among the four-year institutions of higher education."

The committee went on to assert that "continued budget allocation below formula levels will, however, inevitably result in serious sacrifices to safety, security, sanitation and support services for the institution's instruction, research and service activities." They concluded that substandard maintenance results in the "acceleration of depreciation and deterioration requiring costly repairs."

Building Maintenance

Interestingly enough, the committee rejected a building maintenance formula that has a gross square footage base because:

- "The facilities of a typical college or university include warehouses, temporary structures and other buildings constructed at times when lighting and ventilation standards were lower than those now in effect.
- The use of a composite cost per square foot to determine future requirements assumes that the levels (of maintenance) adequate for the existing structures are appropriate for new space. This assumption is inaccurate since maintenance costs are higher for new construction which contains complex mechanical, electrical and ventilation facilities.
- The use of historical square foot costs assumes the adequacy of present allocations.
- There is no built-in safeguard against inflationary costs.
- Due to the difference in the mix of age and type of buildings, no standard for interinstitutional comparison is provided."

The committee went on to recommend the same building replacement cost approach first proposed by Kraft and subsequently adopted in Texas and Florida. They used the same three building types together with the same six maintenance costs factors used in Texas and Florida. The Washington formula defined the initial acquisition cost of a building as follows:

> "In order to obtain consistency in procedures followed to compute the current replacement cost of buildings, construction and acquisition costs are defined as follows:
>
> 1. The full construction costs of a building include: Basic construction contract costs, utility and site costs to a point five feet outside the

building, architectural and engineering expenses, professional service costs, project supervision and other on-site inspection service costs such as surveys, test boring, etc., and fixed equipment.

2. Full acquisition costs including legal fees, etc."

These are broad definitions reflecting total project costs, not just construction cost.

Custodial Services

While the committee agreed that "though 15,000 gross square feet per janitor would permit the achievement of an optimum standard," they adopted a standard of 20,000 gross square feet as acceptable, provided an additional allowance was made for supervisors and relief staff to fill places of janitors temporarily absent from work. The formula adopted is as follows:

1. Allow 1.0 FTE janitor for every 20,000 gross square feet of space maintained.
2. Allow 1.0 FTE window washer for every 350,000 gross square feet of space maintained.
3. Multiply the positions computed in (1) and (2) above by 1.1375 to provide 1.0 FTE relief worker for every 12 formula FTE and to provide 1.0 FTE supervisor for every 20 FTE employees.
4. Compute janitorial salaries budget by multiplying the result of (3) above by the "average worker-year cost."
5. A supplies budget was determined from the base year of the formula on a per FTE basis and adjusted upwards for inflation in subsequent years.
6. An allowance for equipment replacement was computed by allowing $0.0092 per gross square foot maintained per year.

Grounds Maintenance

The committee based its grounds formula on an analysis of the types of landscaping to be maintained. They identified four types, each with its own manpower standard:

1. Very High Intensity Landscaping. Allow 1.0 FTE for every four acres to maintain highly refined planting areas adjacent to structures, plazas, campus entrances, and the like.
2. High Intensity Landscaping. Allow 1.0 FTE for every eight acres of improved areas having unsprinklered lawns and a high incidence of shrubs and trees.
3. Medium Intensity Landscaping. Allow 1.0 FTE for every 16 acres of improved areas having sprinklered lawns and a low incidence

of shrubs and trees. This classification also includes roads, walks, and other paved areas.

4. Low Intensity Landscaping. Allow 1.0 FTE for every 32 acres of all general areas in a wild or natural state and those with limited improvements where maintenance methods are simple and less frequent attention is required.
5. Multiply the positions computed in (1), (2), (3), and (4) above by 1.1375 to provide 1.0 FTE relief worker for every 12 formula FTE and to provide 1.0 FTE supervisor for every 20 FTE employees.
6. Compute the grounds maintenance salary budget by multiplying the result of (5) above by the "average worker-year cost."
7. A supplies budget was computed as "a factor of 10 percent of the building maintenance allowance."

Utilities

A utilities formula was also developed; but, since it presupposed fairly static energy costs, it is not generally applicable. No formulas for physical plant administration, security, and other general services were proposed since these were considered to be "noncomparable elements."

5.5 THE COLORADO SYSTEM

The formula developed for Colorado applies only to ongoing or routine physical plant operations and maintenance, which is defined to be those costs included in the *APPA Classification of Accounts for Physical Plant* but excluding the costs of purchased utilities, excluding replacement costs of departmental equipment, excluding the costs of Major Repairs and Renovations (Special Line Items), and including the costs of operating and maintaining utility generating and distribution systems. See Part II, Chapter 4 for "Classification of Accounts for Physical Plant." Routine Operations and Maintenance is taken to include the costs of physical plant administration (including campus environmental health and life-safety programs), building and equipment maintenance, custodial services, utilities generation and distribution, and grounds maintenance, all as defined by APPA.

It also includes the following Other Services: Campus Security, Property Insurance, Bus Systems (unless self-supporting), Fire Protection, Safety, Solid Waste Disposal, and Trucking and Moving.

Criteria

The committee was directed to develop budget formulas that would "equitably distribute physical plant resources among the public institutions of higher education." The committee was further directed to establish a base year from which all formula calculations would proceed and such that the formula would allocate the *same* resources to that base year as were actually provided statewide. The formula was, from the outset, not to generate ideal budgets in any sense of the word. The committee established the following additional criteria for the formulas to meet:

- The input data must be easily obtained and readily verified by audit.
- The input data must bear an acceptable and logical relationship to the functions of the physical plant.
- The input data should lend themselves well to interinstitutional comparisons.
- The formula must be as simple as possible in order to be easily understood.
- The formula must produce unambiguous results that satisfy the needs of a variety of state-supported institutions of higher education.
- The formula should provide a logical basis for staffing and budgeting new or emerging institutions.

The committee relied heavily on formula work already undertaken in Oklahoma, Texas, Maryland, Florida, and Washington and concluded that all these approaches had at least some undesirable aspects. None of the formulas studied actually encompassed all physical plant functions. The formulas that relied on the replacement cost approach were felt to require inordinate amounts of input data.

While a number of formula reports gave lists of reasons for rejecting a maintenance formula founded on gross square feet, most authors agreed that nearly perfect correlations exist between maintenance budgets and gross square feet of space. The Maryland approach was investigated in depth; but, in the end, it was rejected because it allocated the same staffing per square foot to both large and small institutions when scale problems are known to exist.

Most of the earlier formulas typically used a disaggregated approach in that separate formulas were developed for each physical plant function, which may unnecessarily restrict variation in institutional policy and management.

Plant Application

In the end, the Colorado committee concluded that the single input variable most closely related to the physical plant mission is size: The larger the institution, the more physical plant resources are required to operate and maintain it.

A second important factor is a measure of the intensity with which space is utilized. The committee elected to use gross square feet of space per full-time equivalent student (GSF per FTSE) as a measure of intensity of use. The lower this number is, the heavier is the utilization and vice versa.

The Physical Plant Operations and Maintenance Formula recommended by the committee may be summarized as follows:

1. Workload Standard = 8,500 + 0.001 (Gross Square Feet)
2. Basic Formula FTE = $\dfrac{\text{Gross Square Feet}}{8{,}500 + 0.001\ (\text{Gross Square Feet})}$
3. Adjustment Factor = 1.25 - 0.0025 (GSF/FTSE), for GSF/FTSE less than 100;

   Adjustment Factor = 1.00, for GSF/FTSE larger than 100.
4. Adjusted Formula FTE = (Basic Formula FTE) x (Adjustment Factor)
5. Unit Budget = (Unit Budget from Prior Year) x (Inflation Factor)
6. Formula Dollar Budget = (Adjusted Formula FTE) x (Unit Budget)

> Note: Staffing is based on 1 full-time equivalent employee for every 8,500 gross square feet. Large universities use 1 FTE for every 12,500 GSF.

The formula permits a certain amount of flexibility. For instance, it was observed that salaries, wages, and benefits formed a stable 72 percent of the total physical plant operations and maintenance budget over the years under study. This permits annual development of separate inflation factors for the two major components of the Unit Budget. That is, a materials and supplies inflation factor may be applied to 28 percent of the Unit Budget, while a different inflation factor may be applied to the 72 percent salaries, wages, and benefits component if there have been, or are expected to be, differential price movements. Overall, the Colorado formula has the benefit of being easily modified to generate richer or leaner budgets to meet changing appropriations climates.

5.6 CONCLUSION

A variety of physical plant budget formulas and models are available. They range from relatively simple, highly aggregated formulas to complex, detailed, and quite disaggregated models. The formulas presently in use serve a variety of purposes. Some have originated within the higher education community as a means to unify the budget request process behind a common strategy. Others have been imposed upon higher education by governing boards, state executive branches, or state legislatures. Ideally, the formula will be acceptable to all sectors and will result in adequate and equitable levels of maintenance. Circumstances of the specific situation will dictate the type of formula selected.

While formulas provide a means for institutions to determine future funding requirements based on some fixed factors, they are not without flaws. For example, one drawback to formula budgeting is the emergence of the linear cost syndrome, a situation in which funding becomes tied to enrollment figures. During periods of enrollment decline, linear formulas can be disastrous—especially when state legislatures fail to fully fund formula requests. At these times, institutions can only realize marginal reductions in expenditures, and the amount of such savings depends upon many factors.

Another formula pitfall, which has greater impact during periods of steady-state or declining enrollments, is the self-fulfilling average cost prophecy. This can be a problem in those states that use statewide averages for their formula factors. During periods of stable or declining enrollment, and consequent stable or declining funding, the formula can become an expenditure-leveling mechanism among institutions in the system. That is, the state system may actually allocate funds among institutions based on the formula, forcing each institution to operate at statewide average costs. Thus, the self-fulfilling average cost prophecy will be realized.

Equally unfortunate is the "numbers game" that can be created by enrollment-driven formulas. With these formulas, enrollment dropoffs spell funding reductions. For instance, the decline in college and university student rolls during the 1970s and early 1980s intensified competition for students among institutions, leading in some cases to dubious recruitment ethics and a compromise of educational standards.

Whatever formula is chosen, it should have the following characteristics:

- The formula should inject objectivity into the budget process.
- The formula should improve or maintain the equitability of treatment of all participating institutions.
- The formula should provide demonstrably adequate, but economical, budget levels.
- The formula process should be as simple as possible so that it can easily be presented to laypersons.
- The formula should use quantifiable input data that are easily obtained (by even the smallest participating institution) and that can be easily audited.
- The input data should bear an acceptable and logical relationship to the physical plant function.

- Both the input data and the formula results should lend themselves to ready comparison with other institutions both internal and external to the system.
- The formula should precisely define those institutional functions and costs to which the formula allocates resources.
- The formula process should preserve institutional management flexibility to the maximum extent possible.
- Finally, in times of declining enrollments and tightening budgets, an acceptable formula must be adjustable to meet changing appropriation and budget climates.

CHAPTER 6

Fundamentals of Zero-Base Budgeting

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6.1 ZERO-BASE BUDGETING AS A CONCEPT

Zero-base budgeting is a formal process by which resources are allocated on the basis of projected results. The process is simple in concept. Activities are identified, alternatives are considered and evaluated, choices are made and implemented, and results are monitored.

Given a group of desirable activities termed "decision units" that compete for limited manpower and other resources, those activities ranked highest in priority are allocated the available dollars. The essence of the concept is that for each identified function, task, or activity to accomplish, the manager justifies "from base zero" the expenditures he or she proposes to make and then rank orders all competing activity proposals by importance or priority.

Zero-base budgeting reorients the traditional thinking about the budgeting process. Traditionally, managers accepted the previous year's budget level as the base and then attempted to justify increments above that. In terms of line items according to the accounting system's chart of accounts, the focus was usually on separate types of expenditures rather than the programs those expenditures helped to carry out. Starting from zero base each year, however, requires managers at all levels to determine how they are going to run their operations in the upcoming year. It forces them to identify what activities and programs will accomplish the results desired.

The underlying principle of zero-base budgeting is that simply because an operation or program was funded in the past, it does not follow that it should automatically be funded in the current year. Instead, new missions emerge and old projects wind down. Both get reflected in the budget.

In its simplest form, zero-base budgeting is a periodic reevaluation of all of the department's operations and programs.

6.2 ORGANIZATIONAL EFFECTS

Zero-base budgeting illuminates and formalizes several factors relating to the successful operation of an organization. For example—

- It recognizes that the budget-making activity is critically important in the decision-making processes.
- It forces good management practices to be followed and coordinates them with, and integrates them into, the budget-making activity.
- It identifies the consequences of adding incremental amounts of money, in increments above zero, and identifies the consequences of committing or not committing the resources to the activity.
- It forces order into a thinking process that should be natural to managers. It emphasizes jobs to be done and the priority order in which they should be accomplished. It focuses upon measuring workloads and other input resources. It places emphasis upon measuring performance, putting stress on the results of the activities that are implemented.

6.3 STEPS IN THE PROCESS

Assembling a zero-base budget can be accomplished in steps. The basic steps are highlighted below.

- Develop assumptions to underlie the planning to be done and establish guidelines on wage increases, inflation for materials, student enrollment, etc.
- Identify the decision units within the organization.
- Prepare the decision packages for activities within the decision units.
- Review the decision packages and rank them in priority order.
- Allocate the resources and communicate the approved budget to operating managers.
- Evaluate the results from implementing the activity plans.

Identifying Decision Units

The implementation process starts with identification of all decision units within the department. A decision unit is a tangible activity or group of activities for which a single manager has the responsibility for successful performance. The identification may vary. A decision unit may be one of the following:

- Cost center or profit center (carpenters, painters, etc.).
- Group of people working toward a common goal (safety committee).
- Project or program (carpet installation in dormitories).
- Services provided or received (engineering department).
- Expenditure objective (project not to exceed fixed cost).
- Capital expenditure program (alteration project).

The feature common to all decision units is that of a measurable output resulting from the resources committed to the unit in the budget year. Therefore, a constraint on how a decision unit is defined is that there must be within the accounting system (or in an informal reporting system) some means of measuring, on a systematic and periodic basis, the physical progress and resources consumed by the activity.

The implementation structure for zero-base budgeting is built around the identification of the decision units in the organization and the clear delineation of the managerial hierarchy that will be involved in the process of ranking the decision packages submitted by decision units.

Generally that hierarchy will follow the organization chart in terms of authorities and responsibilities, but there may be other relationships which exist that are more appropriate for the ranking. Each situation is different, and the best hierarchy must be determined from the circumstances.

Determining Decision Packages

A decision package is a document or form submitted by the decision units that describes the activity and lists the following items:

- Description of the function.
- Goals or objectives of the function.
- Specific measures of performance.
- Benefits to be derived from funding the activity.
- Consequences that would result from not funding the activity.
- Projected costs of the package.
- Alternative ways of performing the same activity.

Given the characteristics of the organization and personal preference, others may exist.

Decision packages are formulated in either of two, or in both, the following ways:

- Mutually exclusive or separate packages are developed that identify alternative ways of performing the same function. The alternatives are then ranked and the best one chosen. The other packages are either deferred or discarded.
- Incremental packages emerge that identify sequential levels of effort and funding that may be expended on a specific function.

Ranking the Decision Packages

The process of ranking decision packages begins in the following way. The manager arrays the incremental decision packages for each discrete activity from most essential to least essential. By doing so, the manager establishes initial rank order for the decision package series within his or her jurisdiction.

A manager would typically have several functions within his or her jurisdiction, with each function possibly being subdivided into several activities. The manager of the function would have to rank order the various incremental effort-level activity decision packages from most important to least important.

Then the manager passes this ranking and the decision packages up to his or her supervisor for consolidation with those from other managers. The supervisor reviews his subordinates' rankings and consolidates all decision packages into a single ranking for his level of responsibility. That, then, is passed upward for the next level of consolidation and ranking.

Ranking by committee usually takes over from this point. As the decision packages are consolidated and reranked, the perspectives and objectives broaden. That is why rerankings are commonly performed by committees.

The committee will focus its attention on those packages at the margin of being funded or not funded. A 'cutoff point' may be used to facilitate the ranking of the competing packages at the various levels.

6.4 FOCUS ON DECISION UNITS

The subject of each decision unit is *always* an identifiable activity. The way an activity is conceived or the predominant characteristic of the activity, however, is another matter. That is the focus of the activity.

Decision units may focus on one or a combination of several possibilities:

- Organizational units.
- People.
- Projects or programs.
- Services received or provided.
- Objective of expenditure.
- Capital expenditures.
- Cost reduction or revenue enhancement.

Each possibility is explored in more depth.

Organizational Units

Cost centers, profit centers, or investment centers are probably the easiest focus of decision packages. They would normally coincide with the established organizational chart and are usually easily subdivided into smaller identifiable activities and tasks.

Individuals or Groups of People

Decision packages may be built around individuals or people acting as a group and performing a particular function. Managers are frequently task-oriented or people-oriented, both of which are amenable to zero-base budgeting. People are frequently the focus of decision packages when—

- Costs of the activity are predominantly people oriented.
- Various levels of personnel effort can be identified.
- People perform identifiable tasks.
- Tasks performed can be modified, consolidated, or eliminated by management decision with relative ease.

Projects or Programs

Projects or programs frequently are the focus of decision packages since they usually form discrete activities and naturally demand specific measurable results. Compared to decision packages built around people-oriented activities, projects usually rely on a greater variety of types of resources and incur a greater variety of types of costs. For instance, a project may require wages, materials or supplies, capital expenditures, facilities, and various support expenditures such as travel or insurance.

Services Received or Provided

If services are received from outside vendors or from other units within the organization on a transfer-price basis, it may be appropriate to identify these services as separate decision packages.

Services provided may be a proper focus for decision packages if the decision unit provides services or benefits to either internal or external entities, especially if those entities are billed for the work performed.

Capital Expenditures

Capital expenditures traditionally have been considered on a separate-project basis, related to but not closely integrated with other expenditure programs. They have been presented as separate proposals or as competing mutually exclusive proposals. This approach to evaluating alternatives coincides closely with, and is easily adaptable to, zero-base budgeting.

The decision package preparation and evaluation procedures gives management the opportunity to rank order the alternative approaches and the incremental options, and to evaluate these in the same context as all other expenditures. If a separate capital expenditure budget is desired, one is easily prepared from the resulting rank ordering and funding decisions.

Cost-Reduction Programs

Generally, programs designed to reduce costs or enhance revenues would have characteristics similar to some of those mentioned above.

6.5 OBSTACLES TO DEVELOPING DECISION PACKAGES

Preparing decision packages is hard work. It requires lots of thought buttressed by clear statements of objectives, delineations of responsibilities, and specifications of performance standards. These are not easy to develop. Some problems are commonly experienced in developing decision packages. An awareness of these obstacles before launching into the process full-scale will likely result in a more successful budgeting process. What follows is a highlighting of some problems that are commonly experienced.

For instance, deciding on what activities are appropriate for decision packages is not always simple. It is necessary to analyze a function by breaking it into discrete activities and then subdividing those into what are essential and what are optional. This is an arduous undertaking.

Establishing incremental levels of accomplishment clearly is necessary, but dividing the activity into incremental levels creates difficulty in determining the appropriate size of each incremental effort level.

It is clear that a minimum effort level must be determined. However, oftentimes that determination is not clear and judgment comes into play. The tendency is to establish the minimum effort level at the current operating level and to then justify expansions beyond that in the incremental effort levels. While the current operating level may in fact be the minimum one, typically it is not. Managers who claim that the current operating level represents the minimum should bear an extra burden to justify that claim.

A tendency to protect positions may interfere with the realistic development of certain decision packages. In a reduced-effort decision package, there is a general trend to retain positions. Therefore, the amount attributed to personnel cost may be out of proportion to what is reflected in other effort-level decision packages.

Identifying standards of performance can prove difficult. Some activities have easily identified and quantifiable measures of work performance. Standards may be devised and followed. On the other hand, many types of activities have none.

Overcosting may result from managers who are protective of their turf. For example, managers preparing decision packages may be inclined to engage in gamesmanship when preparing decision packages. Since overestimating costs may provide some leeway for rising costs or bad predictions, the manager may feel more comfortable with the insulation. However, an effective review and ranking system, as well as a department-wide education program on the merits of properly constructing the decision packages, should minimize the tendency to overcost. If the inclination to overcost is not overcome, loose and less effective budgets will result.

High-priority activities may escape close scrutiny if a conscious effort is not made to prevent this from happening. High-priority activities usually surface quite readily in the budgeting cycle. There may, however, be a tendency to pay minimum attention to the content of these decision packages on the basis that the marginal activities require the greater proportion of time to evaluate. High-priority activities, therefore, may reflect costs that, while not deliberately overstated, have not been subjected to careful investigation. An antidote is for the ranking team to evaluate all packages consistently.

Finally, during the process of ranking decision packages some procedural questions may arise. The individual or the committee ranking the decision package must decide which decision packages are to be reviewed, which decision packages are to be ranked, what voting procedures should be used, by what method the procedural packages should be presented, how the final ranking should be determined, and many other operational questions.

6.6 OBJECTIVES OF ZERO-BASE BUDGETING

Zero-base budgeting can be used as a tool for systematically evaluating the activities of an organization to accomplish effective planning, resource allocation, and management control. For instance, activities can be analyzed in terms of their benefits and costs and in terms of the consequences of doing them and not doing them. Thus, the pros and cons can be weighed with more ease.

Managers of the activities must justify their budget requests from "base zero," not merely as an amount added onto the prior year's allocation. In addition, managers are able to specify the amount, quality, quantity, and cost of their activities and have them compete with other activities for funding on the basis of their projected benefits.

The process is a planning and decisionmaking technique in which the end product is resource allocation for the next year. Finally, this budgeting process helps determine what to do, how to do it, why it is being done, and what the cost will be.

6.7 BENEFITS OF ZERO-BASE BUDGETING

Starting with a clean slate each year before working up an annual budget brings certain benefits to organizations. Among them are the following:

- The budget process becomes one of analyzing the options, weighing the trade-offs among them, and deciding on the resource allocation on the basis of greatest relative benefit.
- The technique integrates planning and systematic decisionmaking into the budgeting exercise.
- The procedure provides a systematic means by which managers continually evaluate in detail the efficiency and cost-effectiveness of their activities.

- The method affords a means of identifying for consideration new programs or new ways of performing continuing activities and having them compete for funding on their merits rather than always taking second place.
- The process allows trade-offs between long-term goals and short-term objectives or needs, based on the projected costs and benefits.
- The method simplifies **and systematizes follow-up on the performance as measured against the projected costs and benefits.
- The technique provides flexibility whereby progress can periodically be reevaluated, with possible reallocation of resources based on performance. The flexibility also allows accommodation to changes in revenues generated.
- The procedure simplifies identification of similar functions or tasks in different departments for comparison, evaluation, and establishment of common work measurements.
- The process pulls the operating managers into the planning and implementation phases, which forces a commitment to the programs they recommend.
- With the zero-base method, decision packages that do not change in subsequent budget cycles need only to be reranked with the other packages submitted for consideration.
- The approach provides management the opportunity to understand the nature and interrelationships of the activities in which the organization is engaged and how these support the overall goals.
- This form of budgeting shifts the responsibility for recommending activities to the operating managers, for evaluating their priority to all levels of the organization, and for funding to top management.
- The technique shifts the focus of budgeting from performing numerical computations to decisionmaking at all levels of management.
- The procedure shifts the focus from the amount of the expenditure to its effectiveness, which is measured by prestated standards.

6.8 PERSPECTIVES ON THE PROCESS

Zero-base budgeting is a broad tool for the effective planning and control of service and support activities and for allocating available resources to those activities on the basis of greatest benefit to the organization.

Three key features may be identified:

- The cornerstone to this method's success is for top management to understand the concept thoroughly and support its implementation wholly.
- The involvement of the operating managers in the process and their commitment to attain the results projected for the activities they recommend is essential to the success of the process.
- The process forces a systematic investigation of how best to achieve the objectives set out for the organization as a whole as well as for the individual units.

This form of budgeting forces a greater interaction and mutual reliance between departments than other budgeting systems. Good managers will be able to direct this interaction to a successful team effort. That team effort is essential to the successful implementation of zero-base budgeting in an organization.

The principles of the process are sound. They can aid in any budget process even if the zero-base budget format is not used in its entirety.

CHAPTER 7

Zero-Base Budgeting as a Technique

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7.1 THE CONCEPT AND COMPARISON

Zero-base budgeting was first introduced in 1970 by Texas Instruments, Inc.[1] The firm initially applied the technique to develop its staff and research budgets and then in 1971 extended its use to all nonmanufacturing budgets. Since that time both private and government bodies throughout the country have also successfully employed this technique.

A system that requires each function, activity, or program to be justified on the basis of its own merit to the organization, zero-base budgeting calls for resource allocations to be committed only after each activity or program is analyzed and justified from "scratch" or "base zero." Thus the term "zero-base budgeting." This approach requires all activities to be identified in decision packages which are then evaluated by systematic analysis and rank ordered according to importance. While it can be demonstrated that zero-base budgeting is a form of comprehensive budgeting, it can also be shown that it goes much further in the demand for analysis and proof of funding need than do other budgeting methods.

The technique focuses on those activities most fundamental to achieving the organization's goals and objectives. It specifically requires that all activities be reviewed in their entirety each budget cycle.

Because the process is a structured and formalized one, it requires management to plan and analyze activities and programs more carefully than may otherwise be done. Management must take the following eight steps:

- Define goals and objectives.
- Identify assumptions necessary to facilitate planning and budgeting.
- Identify decision units within the organization.
- Develop decision packages for activities within the decision units.
- Review the decision packages and rank them in priority order. Ranking is based on how closely the item meets the organization's objectives.

- Develop alternatives and consider their results.
- Prepare and authorize the budget. Allocate the resources.
- Monitor and evaluate the results.

The process, which employs in-depth planning and analysis, emphasizes the importance of the budgeting activity in the decision-making process. It forces numerous levels of managers to become substantially involved as they identify specific activities associated with decision packages. In addition, the process identifies the consequences of committing or not committing resources to an activity and the results of considering incremental allocations above the base zero. Thus, each additional increment is considered on the basis of its specific cost and associated benefit to the organization compared to other activities also vying for resource allocations.

Zero-base budgeting reorients the traditional thinking about the budgeting process. Traditionally, managers accepted the previous year's budget amount as the base and then simply attempted to justify increments above that level. The focus was upon individual types of expenditures rather than those programs the expenditures helped to accomplish. The zero-base budgeting method, however, requires managers at all levels to take a fresh look each budget cycle at how they are going to manage their operation and at what activities and programs will accomplish the results they desire.

The underlying assumption of zero-base budgeting is that simply because a program was funded in the past does not mean that the program should automatically be funded in the future.

Traditional budgeting does not provide an impetus to reexamine activities or programs on a regular, in-depth basis. The assumptions are that the activities are necessary and decisions are usually made to either maintain the allocation at the previous year's level or, if funding is available, add to it. If funds are limited, allocations are usually kept at the same as the previous year or are cut without a detailed investigation and insight into the anticipated impact that zero-base budgeting demands. It is often the case with the traditional method that management imposes across-the-board increases or reductions because adequate details and substantiation for selective allocation simply do not exist.

Zero-base budgeting is truly a management-oriented tool. Identifying the individual activities and programs, the resources required by each, and the prospective results require substantial time and effort. As a result, staff members who are most knowledgeable about the intricacies of the activities are drawn into the analysis. This involvement buoys morale and prompts a commitment for success. It also forces individual managers to consider different ways of performing activities or to weigh alternative methods of attaining specific results.

Perhaps its greatest asset to plant managers lies in its usefulness as a decision-making device. For even if a budget is approved based on the traditional approach—which uses last year's figures as reference—the manager can use zero-base budgeting with its prioritization to quickly determine which programs to eliminate and which to retain.

In sum, zero-base budgeting can be defined as a technique that allocates resources according to intended results. Managers specify the results they expect to obtain within each organizational unit and then allocate the resources needed to achieve them.

7.2 SPOTLIGHT ON THE PROCESS

The eight steps for preparing a zero-base budget were presented earlier as a generalization for the user's convenience. What follows is an expanded description of the procedure. Throughout the chapter a building maintenance operation associated specifically with painting will be used as a concrete example to explain the concept.

Step 1: Define Goals and Objectives

Basic to effective management is the definition of goals and objectives so that all concerned understand what must be accomplished. In other words, it is essential to know one's destination before planning the travel route. Goals, therefore, should be formulated in terms of both general application and specific definition. Using the building maintenance painting operation as an illustration, what follows are appropriate goals.

General Goal: Provide a maintenance service that will result in an environment conducive to the education of students. This would include providing residence hall and food service facilities.

Specific Goal: Paint building interior walls once every seven years with semigloss latex paint to maintain an attractive and protected structure.

Step 2: Identify Planning Assumptions

It is here that the real substance of zero-base budgeting begins. It is essential at this stage for managers to define assumptions relating to such considerations as the inflation rates, salary increases, level of service—much as is done when developing traditional budgets. The more comprehensive the development of the assumptions, the more easily the process will proceed and the more accurate the budget will be.

For example, differing inflation rates may have to be assigned depending on whether or not the considerations are material or labor. Furthermore, different rates may have to be assigned according to the type of material or the classification of the labor. When considering the painting function, one may wish to consider one inflation rate keyed to petroleum-based products and a different inflation rate for synthetic materials that are more readily available and less sensitive to the world's supply and demand. The same holds true for salary increases. Different employee groups may be associated with different bargaining groups, which result in different pay percentage increases.

Step 3: Identify Decision Units

A decision unit is a single activity or group of activities which a single manager has responsibility to carry out in line with prestated goals and objectives. A decision unit must be one for which the manager has sole control. It cannot be an activity such as training if that is the responsibility of numerous managers in many departments. A typical decision unit is a specific cost center, project, program, or service provided.

Regardless of how the decision units are identified, they must be units that will lend themselves to quantifiable measurement. It is essential to be able to regularly measure the resources employed and consumed and to determine that tangible progress is being made toward meeting objectives.

Step 4: Identify Decision Packages

Decision packages can be thought of as components within decision units. The packages provide further detail or elaborate on the decision unit. For example, when dealing with a plant operation, the plant division could be considered the decision unit and the painting department within the plant division could be considered the decision package. Similarly, a business office could be considered the decision unit while its components of accounts payable, accounts receivable, student collections, and payroll could be considered decision packages.

Step 3 makes clear the importance of involving managers who are intimately knowledgeable about the specific decision units. Using the painting operation as an example, the decision packages should, at a minimum, include the following components:

- Description of the cost center or service to be provided. Example—painting of all buildings and equipment.
- Goals or objectives. Example—paint building interior walls once every seven years.
- Specific measures of performance. Example—paint 300 square feet of wall surface per productive workhour.
- Benefit derived from funding the activity. Example—will not only result in a more attractive environment but will also protect the wall.
- Consequences of not funding the activity. Example—attractiveness of the facility would deteriorate to the point that faculty, staff, students, and visitors would prefer to go elsewhere for education or other activities; building would physically deteriorate.
- Projected costs of funding the activity. Example—$300,000 for in-house materials and labor.
- Alternative ways of performing the activity. Example—contract the service to a commercial painting contractor.

Decision packages are formulated either as mutually exclusive or incremental packages. Alternatively, the packages can be developed by using both techniques. Mutually exclusive packages require the development of alternative methods of performing the same function. Each alternative is considered and ranked, and the best chosen for implementation. The procedure compels managers to think creatively and to identify more efficient methods of performing functions rather than simply stating different ways of performing the same function.

Incremental packages are developed by identifying the most basic or minimum service that can be provided. The specific increments are devised, including the benefits and costs that they entail. They are evaluated increment by increment until a total package is eventually formulated.

One advantage of this method is that it forces managers to carefully consider the absolute minimum that can produce a meaningful result. If a more thorough approach is desired, both exclusive and incremental packages can be used. For example, alternatives can be developed and then increments devised for each alternative. While this combined approach results in a thorough evaluation process, it does demand more time and effort.

This step in the process requires the greatest effort on the part of staff. It is also the most time consuming. Since organizations are seldom able to assign to the task additional personnel who are adequately knowledgeable in specific substantive areas, the regular staff members are responsible for carrying out the effort. The first year that zero-base budgets are developed and implemented requires the most attention. Subsequent years become easier as the staff becomes familiar with the process. It is essential, however, that zero-base budgets be prepared with the input of the most knowledgeable first-line managers as well as higher-echelon managers. That means that sufficient time and effort must be allocated. For without the appropriate commitment and support, the resulting budget will fall short of the desired results.

Step 5: Analyze and Rank Decision Packages

Ranking can be accomplished in a couple of ways. It is most commonly performed at various management levels. For instance, the supervisors who developed decision packages must carefully consider those packages and rank them from most important to least important for their area of responsibility. A written explanation should accompany the ranking that details the associated costs and benefits. If incremental packaging is used, the package should be proposed with both an "absolute essential base" and individual increments. Each increment must include a statement of costs and benefits that would be keyed to the effort.

Step 6: Develop Alternatives and Consider Their Results

Alternatives should also be developed and presented for each package. They should be presented by stating the different ways a function can be performed and by identifying the different levels of effort at which each function can be performed. The decision-making process is two-pronged: selecting the particular way the result will be achieved and determining what resources are to be used to achieve that result. In arriving at a decision, the incremental technique at times affords a better opportunity to garner support for a package, while the mutually exclusive method may result in an all-or-nothing situation.

The decision packages are then passed up to the next level of management for consolidation with those from managers of other functions. Generally, the rankings are then reviewed by a committee. The committee focuses most of its attention on those packages at the margin of being funded or not funded as defined by the group's criteria. It is unlikely that those packages designated "absolutely essential" will have to be considered unless budgetary retrenchment is severe. For this reason it is important that criteria for ranking be well defined so that only those packages that are "absolutely essential" are labeled as such.

During the rating process, the highest level manager from each unit should have an opportunity to present to the committee the rationale for prioritization. A question-and-answer period should be set aside so that each committee member obtains a thorough understanding of the packages.

Committees will often use a cutoff point or payback criteria to assist in the ranking process. Final ranking can be achieved simply by assigning a numerical priority.

Step 7: Prepare and Authorize the Budget and Allocate Resources

Once the final ranking is completed, preparing the budget and allocating financial resources is quite straightforward. A cutoff line is drawn at the point where the package costs above the line add up to the total sum available for that budget period. Decision packages above that line will be funded while those below it will not. For monitoring purposes, the final budget can be formatted in the same way as traditional budgets.

Step 8: Monitor and Evaluate the Results

A budget is only as effective as its monitoring and control. Zero-base budgeting is no exception. While it had been important to identify priorities for funding allocation during the budget formulation stage, it later becomes important to operate effectively within those funding limits.

Individual unit managers should be authorized to monitor and control their staff's performance and budget allocations. Continual general review should be left to the manager of the subunit. Involving subunit managers instills a sense of pride in these persons. It also requires them to focus attention on their functions in a way that stimulates them to perform well and operate within the confines of their budgets.

The zero-base budgeting process provides financial and performance measurement data that are useful for monitoring purposes. Examples of statistics that are recommended are—

- Basic monthly data comparing actual expenditures against budgeted projections.
- Monthly workload and performance data to assure that the subunits are accomplishing their projected results.

Performance feedback will indicate if personnel are appropriately productive, who is the most efficient, and if work time is being used effectively. It will also show if staff performance results are in line with expenditures for materials or if personnel assignments should be modified to meet the objectives. For example, if standards were developed to identify specifically what was expected of painters, the supervisor could—

- Compare the actual painter's performance against the standard.
- Compare painters' productivity to encourage competition. The most productive staff would be rewarded.
- Measure painters' nonproductive time against productive periods to determine if improvements should be made such as scheduling more effectively, minimizing travel time, or adhering more closely to break periods.
- Evaluate the most cost-effective way to assign painters, either individually or in teams, based on the individuals' productivity.

With these data in hand, the supervisor can take whatever action may be needed to improve the efficiency of the painting staff.

This information provides a tool for the subunit managers to evaluate their staff and gives upper level managers a means of evaluating the effectiveness of the subunit managers.

7.3 PHYSICAL PLANT APPLICATION

How does zero-base budgeting apply directly to plant operation? It can be applied most readily to personnel. For purposes of illustration we will use an example of a painting operation, a typical decision package.

We will assume that the college or university has already defined its goals and general planning assumptions and has expressed interest in the plant project. The plant manager would then meet with the supervisors of subunits to identify the decision packages. A briefing to explain why the budget is being prepared by the zero-base method would be in order. At the meeting it is important for the plant administrator to walk the participants through the process. Emphasis should be placed on the need for furnishing solid documentation in order to evaluate how well goals are being met. It should be made clear that the viability of each subunit depends upon meeting measurable performance goals. Each supervisor would then be asked to assemble a resource needs document using incremental analysis.

At that point the painting supervisor would begin to develop a decision package. First, general and specific goals would be stated.

General Goal: Provide a maintenance service that will result in an environment conducive to the education of students. This would include providing residence hall and food service facilities.

Specific Goal: Paint building interior walls once every seven years with semigloss latex paint to maintain an attractive and protected structure.

It would then be necessary to identify planning assumptions. Examples are—

- Productivity rates for interior walls.
- Productivity rate for ceilings.
- Definition of what constitutes a productive workhour (pwhr).
- Statement as to whether productivity rates include moving furniture, removing electrical wall plates, taping cracks where necessary, caulking, and working in occupied or unoccupied areas.
- Statement as to whether productivity rates should be determined based on the texture of surface to be painted or whether all surfaces are to be considered equal.
- Productivity rates for each painting method—brush, roller, and sprayer. A statement should note whether all methods are to be considered equal.
- Productivity rates for unique circumstances such as staining stair railings with numerous spindles, door frames, miscellaneous metal, etc.
- Statement declaring whether painters work independently or as a team.
- Statement of material coverage (square feet per gallon).
- Statement noting the frequency of interior painting.

It is advisable to record any special notes. The notes may pertain to how the amount of interior wall area in each building was determined, how the total amount of window sash was calculated, and how the frequency rates were derived. Thus if future modifications need to be made, such documentation not only assures that the same method will be used for determinations but also serves as a help in making accurate comparisons.

Once the necessary data are accumulated, the painting supervisor then begins to formulate the budget. Since it is generally most desirable to use the incremental technique, the supervisor would define the base and the increments needed to reach the established goal. The base may simply suggest that it is essential to paint all interior metal surfaces once every 8 years and all interior nonmetal surfaces once every 12 years.

Increments should then be determined and funding levels assigned to each. The increments should be arrayed from the base activity level all the way up to the goal level. In the example given above, a decision simply may be made to shorten the intervals between painting.

The benefit to be derived from performing the base activity should be identified. In addition, benefits should be keyed to each increment. Whenever possible, a benefit should be stated in terms of actual dollars. Intangibles, however, should not be ignored though they are not always easily quantified. For example, what is it worth to have an unmarked, bright surface as opposed to a marred, dull, deteriorated one?

The consequences to be expected if an activity is funded or not funded must be presented. Thus, both dollar and intangible values must be developed. Using a painting example, the statement of consequences could take the following form:

> If a specific piece of equipment were not painted once every four years, the surface protection would deteriorate such that in six years it would cost twice as much to return it to a satisfactory condition. When metal is not adequately protected it will rust. As a result, it not only requires more time for surface preparation but also requires applications of primer and finish coats of paint. A well-maintained surface, on the other hand, will likely require only one coat of paint or possibly only touchup.

Such information should be well substantiated and clearly defined to promote understanding of this budget item. Calculations could then be made of how many dollars would be needed for labor and materials in order to maintain the facilities at the identified minimum level as well as at each incremental level.

Finally, alternative ways of performing the activity should be identified and considered. Costs must be determined and benefits and consequences analyzed. An example of an alternative way to carry out an activity would be to consider outside contracting for some or all of the institution's painting needs.

Once this were done, supervisors would then prepare and present their budget requests with justification to substantiate each claim. They should be made aware that their presentations have an impact on the upcoming year's budget since they are competing with other subunits for resources.

7.4 BENEFITS OF ZERO-BASE BUDGETING

Organizations can benefit greatly by preparing their budgets in this fashion. Since the budget is not pro forma, it forces organizations to think through their needs and objectives afresh. Some of the benefits to be reaped are described.

- Participants in the process become better informed about their specific operations as well as more aware of the operations of other divisions. This fosters improved interdepartmental relations and mutual reliance.
- Managers improve their communications skills since they are called upon to present their case for human and financial resources. Equally important, they must sharpen their analytical skills since those skills are essential to determining how resources are allocated.
- The method shifts the focus of budgeting from performing numerical calculations to decision making at all levels.
- The budget, once it has been developed, provides managers with a systematic means to evaluate the efficiency and cost-effectiveness of their activities.
- The process provides a way of identifying for consideration new programs or new ways of performing ongoing activities and having them compete for funding on their merits rather than being relegated to secondary status. Thus, it consistently forces participants to be creative and to challenge the status quo.
- Efficiency improves as a result of considering alternative operations methods. Monetary savings can be a subsequent byproduct.
- The method allows tradeoffs between long-term goals and short-term objectives or needs based upon the projected costs and benefits.
- The budget preparation steps simplify the identification of similar functions or tasks in different departments for comparison, evaluation, and establishment of common work measurements.
- The process draws operating managers into the planning and implementation phases and forces a commitment to the programs they recommend.
- The process encourages administrative efficiency. Decision packages that do not change in subsequent budget cycles need only be reranked with the other packages submitted for consideration.
- The practice shifts the responsibility for recommending activities to the operating managers, for evaluating their priority to all levels of the organization, and for funding to top management.
- The procedure shifts the focus from the amount of the expenditure to its effectiveness as measured by prestated standards.
- The procedure simplifies and systematizes the follow-up on the performance as measured against the projected costs and benefits.

- The method provides flexibility for periodic reevaluations of progress with possible reallocations of resources based on performance or to accommodate changes in revenues generated.
- The process can lead to better budgeting because it is a joint effort that draws on collective wisdom.

7.5 OBSTACLES IN IMPLEMENTING THE BUDGET

Probably the greatest problem faced when developing a zero-base budget is to establish and retain commitment to see the process through to completion and implementation. It becomes important, then, for top management to fully support the activity. To ensure success, upper-echelon managers must also build in accountability.

For the process to work well, first-line managers who are likely to be most familiar with the day-to-day details of an operation should be drawn into the process. All levels of managers, however, should participate. And, in the end, the final product must emerge as a useful tool for managers or it will not be used effectively.

Knowing the value of a good budget, management should approach budget preparation with the view that many workhours must be expended in order to harvest the benefits. Budget preparation will be time consuming, particularly during the first year, since staff will have to gear up for the effort while holding down their regular responsibilities. It is essential, therefore, that adequate time be devoted to thinking creatively and accurately.

It would be a mistake to present the process as a totally new and innovative concept that will solve all problems. Instead, it must be identified as another tool to educate and assist staff. If expectations are too great and are not met (or perceived to be met), employees may become frustrated over the long hours of effort they contributed. As a result, management has a vested interest in making the process pay off. Some obstacles are commonly experienced during the process.

For example, deciding on what activities are appropriate for decision packages and then sorting out the "optional" activities from the "essential" ones can be quite involved.

There may be a tendency on the part of managers to establish the minimum effort level at the current operating level and justify expansions beyond that point in incremental effort levels. It is highly unlikely that the current level is the minimum one, and managers who present this case should be asked to justify the claim.

A natural tendency exists to protect positions. Care must be taken to ensure that an appropriate reduction in personnel is related to the reduction in service or support.

Inertia may have built up to judge personnel on past performance rather than on what should be expected. Standards of performance, consequently, must be established carefully and fairly. While various standards may already exist for numerous tasks, it often becomes necessary to adjust the standards to more accurately reflect specific conditions unique to a setting.

At the same time, it is important to guard against arbitrary modifications to nationally established standards simply because one individual does not believe their accuracy. It is a good policy to analyze the basis on which various standards were developed to judge their applicability. If none can be found, which is quite unlikely, an organization can develop its own. Care should be taken to test and substantiate what is developed. A number of states such as Maryland have spent a great deal of effort and money to establish standards. Additionally, corporations, consultants, and the federal government have developed standards suitable for adoption.

Managers may have a tendency to overbudget in order to build in leeway for inflation or bad predictions. If the tendency to pad is not overcome, inaccurate budgets will result.

Finally, high-priority items do not always receive the close scrutiny they should. In organizations there is sometimes a tendency to pay a minimal amount of attention to the content of these decision packages since management realizes their importance and automatically backs them. High-priority packages, therefore, may reflect costs that, though not deliberately overstated, have not been subjected to careful examination.

7.6 SUMMARY

Zero-base budgeting is not an altogether new concept. It has been in existence, though seldom applied, for many years. However, its acceptance has been growing steadily since Texas Instruments, Inc. effectively introduced and applied this management tool in the early 1970s.

It is a technique that, when introduced and supported fully by upper-level management and given adequate time and personal commitment during preparation, can result in a myriad of benefits. It can encourage managers to analyze their operation with a critical eye, measuring them against other goals of the organization. Further, it can help managers prioritize needs in order to make difficult budget decisions. The outcome can be to direct both manpower and monetary resources to the activities that will be most beneficial to the organization.

END NOTE

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ADDITIONAL RESOURCES

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CHAPTER 8

A Business Officer's View of Budgeting at a State University

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The budget process at a state university takes on two identities. There are normally both internal and external involvements in the processes related to the operations and maintenance budget as well as the capital budget. Throughout these processes the plant administrator plays a vital role as both technical expert and liaison.

8.1 OPERATIONS AND MAINTENANCE BUDGET

At a typical public university operations and maintenance of the plant normally represent some 8 percent to 12 percent of the total current fund expenditures. This is a significant proportion of the budget and is often the subject of intense campus scrutiny, bringing with it substantial expectations of accountability.

The chief business officer and the plant administrator share in this responsibility. However, it is normally the plant administrator who carries the yeoman's share of the burden. These two individuals can help each other and keep the campus community informed through teamwork and well-developed communications.

The successful plant administrator is likely to be the one who works diligently to enhance it. He or she has recognized that the business officer sits at a level within the organization that can benefit the overall plant operations. The better the business officer understands the priorities, needs, resources, and services of the physical plant, the more apt the plant department is to receive ample support throughout the budget process.

Plant administrators need to remember that most chief business officers have little if any experience in plant administration. Most likely the business officer will have management experience, some business background, perhaps a budgeting or accounting speciality, but only a passing familiarity with the details of plant operations and maintenance. This is a crucial matter for the plant administrator to understand in order to gain support from the business officer.

The business officer typically expects the plant administrator to administer plant programs and to demonstrate balance among operations, preventive maintenance, renovations, and capital improvements. In this increasingly data-oriented society, it is incumbent upon the plant administrator to collect data that depict the emphasis given to primary functions by the plant department. When presented with meaningful, sometimes graphic, reports on a regular basis, the business officer can better understand and appreciate the programs of the plant department.

Preparing this supporting information in an organized way can expedite the process. Individual services and operational units, for example, should be listed in separate fashion in the accounting system so that detailed reports can be prepared. If users are charged for any services, the basis for the charges should be well-documented so as to be clearly understood by the business officer. It may take several months to determine which data are best used by both the plant administrator and business officer, but the time spent developing the most meaningful reports will be worth the effort.

With a well-established understanding of how the plant department uses it, the business officer is prepared to represent the department during the institution's budget process. While the steps and degree of openness in this process vary from institution to institution, expect some form of review at one or more levels of the organization.

No matter how well-conceived the system or how professional the players, subjectivity enters into the process. Recognizing this fact, the business officer-plant administrator team should reinforce the perception of an efficiently run plant department. Presenting historic figures showing productivity ratios and staffing levels over several years can help build such a perception as well as demonstrate the need for additional support. Showing figures that demonstrate the balance of fixed and variable costs over a similar time period can be equally impressive.

8.2 CAPITAL BUDGET

Unlike the operations and maintenance budget, the capital budget for a public institution has far more external orientation, although there are elements of both internal and external direction in the process.

The very nature of capital budgeting is subject to tremendous variability among public systems. Most often a project is termed "capital" when it fits a particular definition provided by a funding source such as the institution or the federal, state, or local governments. Usually the definition includes some factors such as life expectancy and cost. The plant administrator should be absolutely clear on the definition of capital, for it is he or she who must ultimately make the distinction between operating and capital projects. In most cases that distinction is easily made. Such projects as new buildings, major renovations of existing buildings, or additions to existing buildings are routinely considered capital projects.

Conversely, when offices must be created in a room originally designed as classroom space, the process of adding electrical wiring, wall panels, doors, and the like may or may not be considered capital. The business officer must rely upon the expertise of the plant administrator in arriving at such determinations. See Part V, Planning, Design, and Construction, Chapter 2, "Project Planning and Programming" for a discussion of project categories.

Before a capital project is undertaken, it customarily must survive two processes, one internal and the other primarily external. The first step is normally structured similarly to that established for preparation and review of the operations and maintenance budget. During consideration of capital projects, the plant administrator emerges as the primary staff support. Projects are identified in a variety of ways: through a formalized bottom-up structure, through alumni givers' direct discussions with executive officers of the institution, or through grantors. At this stage the plant administrator, business officer, and prospective users must work together to define clearly the scope of a proposed project.

Once there is a general satisfaction as to proper and adequate specifications, other processes must be set into motion. If a master plan for the campus exists, the project should be carefully checked against it. The financial feasibility of any project should be verified. In states that mandate a prescribed process, this will usually take the form of estimating the cost of a project by formula. The fiscal feasibility should also be verified through informal estimates. Then potential funding sources must be identified, and priorities among projects established.

Throughout all these steps, the business officer and plant administrator must work closely to coordinate with all interested users and groups, with the ultimate goal of involving the institution's governing board and attaining board approval. The plant administrator, through familiarity with the various components of any construction project, provides invaluable support by being fully aware of all details involved—from types of construction, to kinds of material, to scheduling.

The external process begins with board approval of a prioritized list of proposed capital projects. This list is normally communicated in some way to both the executive and legislative branches of state government in the form of a capital request. These government officers and groups may require varying degrees of additional information on any or all projects requested. This part of the process often becomes political, and usually the business officer takes on a far more visible role. However, the person looked to for support throughout this process continues to be the plant administrator who must be constantly prepared to state and restate facts about each project.

Once the external part of the process has been completed, projects have been approved, and in some cases state funding appropriated, both internal and external interactions become a major focus. The plant administrator once again must move to the forefront. He or she must resume work with the business officer to coordinate the many steps involved in seeing approved capital projects to fruition.

It is the plant administrator's responsibility to reestablish contact with users and work with them and architects to finalize planning and specifications for each approved project. The plant administrator or his staff must carefully review working drawings at each phase of completion and must work with required campus committees to ensure that all legitimate concerns have been appropriately addressed in the planning process. At this point the plant administrator takes steps to assure that required procedures are followed in soliciting bids for each project and that appropriate awards are made.

Once construction has begun, it becomes the plant administrator's job to work with the general contractor and any subcontractors to ensure that the institution's best interests are achieved. Through all of these steps, the plant administrator or his staff must also file all required forms and follow the processes mandated by any of several central state agencies involved with capital construction and funding. In addition, the plant administrator's duty is to keep people both on and off campus informed of the status of projects through formal and informal means. For example, the plant administrator should establish procedures with the campus police department for identifying construction crews and their schedules on campus. And he or she should be sure that appropriate participation is solicited from all interested parties whenever last minute changes must be considered and decisions made.

8.3 COMMUNICATIONS ROLE

Overall, plant administrators play a critical role in the development and execution of both the operations/maintenance and the capital budgets of a public institution. As an often transparent, yet strong, arm of the chief business officer, the plant administrator can have a tremendous long-lasting impact on the facilities of the institution. The individual's ability to manage people of varied skills, to communicate with people with various academic and professional training, and to work closely with a financial officer—who often has little or no plant experience—is of utmost importance. If the plant administrator can provide sufficient detail to justify the resources needed to operate and maintain the plant or to complete a capital project, then budget decisions can be made with full awareness of the available alternatives and their advantages and disadvantages.

Probably the single most important way that the effective plant administrator can contribute to any budget process is by carrying on a program of communications with diverse elements of the campus community. Displaying a positive attitude and an abiding concern for the overall good of the institution will contribute greatly to the ultimate success of the plant administrator, the plant department staff, and the institution itself.

CHAPTER 9

Glossary of Financial Terms

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Abatement—A complete or partial cancellation of a levy imposed by a governmental unit. Abatements usually apply to tax levy, special assessment, and service charges.

Accounting procedure—The arrangement of all processes that discover, record, and summarize financial information to produce financial statements and reports as well as to provide internal control.

Accounts receivable—Amount owed an open account from private persons, firms, or corporations for goods and services furnished by an organization.

Accrual basis—The basis of accounting under which all items are recorded when incurred. Revenues are recorded when earned and expenditures are recorded as soon as they result in liabilities even though the actual receipt of the revenue or payment of the expenditure may take place, in whole or in part, in another accounting period.

Acquisition adjustment—Premium paid for a physical asset over and above original cost less depreciation.

Agency funds—Resources held by an institution as custodian or fiscal agent for individual students, faculty, staff members, and organizations.

Aging of receivables—An analysis of individual accounts receivable according to the time elapsed after the billing or due date—usually the former

Allocate—To divide a lump sum into parts that are designated for expenditure by a specific organizational unit and/or for specific purposes, activities, or objects.

Amortization—The gradual reduction, redemption, or liquidation of the balance of an account according to a specified schedule of times and amounts.

Annuity agreement—An agreement whereby money or other property is made available to an institution or individual on the condition that the institution bind itself to pay stipulated amounts periodically to the donor or other designated individuals. The payments are to terminate at a time specified in the agreement.

Annuity funds—Funds acquired by an institution that are subject to annuity agreements.

Appraise—To make an estimate of value, particularly of the value of property.

Appropriation—An expenditure authorization with specific limitations as to amount, purpose, and time; a formal advance approval of an expenditure from designated resources that are available or estimated to be available.

Audit—Examination of documents, records, reports, systems of internal control, accounting and financial procedures, and other evidence to ascertain whether financial information is presented fairly in its entirety.

Auxiliary enterprise—An entity that furnishes a service directly or indirectly to students, faculty, or staff and charges a fee directly related to, but not necessarily equal to, the cost of the service. The public may be served incidentally by some auxiliary enterprises. The services are essential elements in support of the institution's program and conceptually should be regarded as self-supporting.

Balance sheet—A historical summary for a given economic entity of the assets, liabilities, and owner's equity (or fund balance).

Bequest—Property or funds received through a will. Restrictions may or may not attach to use of the property or funds.

Bond—A written promise to pay a specified sum of money, called the face value or principal amount, at a specified date or dates in the future, called the maturity dates, together with periodic interest at a specified rate.

Bond discount—The excess of the face value of a bond over the price for which it is acquired or sold.

Book value (of assets)—Purchase price of an asset less any accumulated depreciation. In the case of an asset received as a gift, it is the appraised market value of the asset as of the date donated less any accumulated depreciation.

Budget—A plan of proposed expenditures for a fixed period or for a specific project or program along with the proposed means of financing the expenditures.

Capital budget—An expenditure plan for adding to or improving plant or equipment. The means for financing for the current fiscal period are included. If a capital program is already underway, the capital budget will be first year of the program. A capital program is sometimes referred to as a capital budget.

Cash—Currency, coin, checks, postal and express money orders, and bankers' drafts on hand or on deposit with an official occasionally designated as custodian of cash and bank deposits.

Cash basis—The basis of accounting under which revenues are recorded when received in cash and expenditures are recorded when paid.

Cash discounts—An allowance received or given when payment is completed within a stated period of time.

Clearing account—An account used to accumulate total charges for credit for the purpose of either distributing them later among applicable accounts or of transferring the net difference to the proper account.

Contingent fund—Assets or other resources set aside to provide for unforeseen expenditures or for anticipated expenditures of uncertain amount.

Contingent liability—Items that may become a liability as a result of conditions undetermined at a given date such as guarantee, pending law suits, judgment under appeal, unsettled disputed claims, unfilled purchase orders, and incomplete contracts.

Continuing appropriation—An appropriation that, once established, is automatically renewed without further legislative action, period after period, until altered or revoked.

Control account—An account in a general ledger in which the aggregate of debit and credit postings for a number of identical or related accounts called subsidiary accounts are recorded.

Cost accounting—That method of accounting which provides for the assembling and recording of all the elements of cost incurred to accomplish a goal, to carry on an activity or operation, or to complete a unit of work for a specific job.

Cost ledger—A subsidiary record in which each project, job, production center, process, operation, product, or service is given a separate account to which all items entered into its cost are posted in the required detail. These accounts should be arranged and kept so that the result shown in them may be reconciled and verified by a control account or an account from the general book.

Coupon rate—The interest rate specified on the interest coupon attached to a bond. The term is synonymous with nominal interest rate.

Credits—The term "credit" relates to the basic accounting equation of "assets equal liabilities and owners' equity (or fund balance)." Credits, on one hand, increase liabilities and owners' equity (or fund balance) and, on the other hand, decrease assets and expenses. The "credit" is the recording entry to the right column in the double-entry accounting records.

Current assets—Those assets that are available or can be made readily available to meet the cost of operations or to pay current liabilities.

Current funds—Resources to be expended in the near term and used for operating purposes.

Current liabilities—Liabilities that are payable within a relatively short period of time, usually no longer than a year.

Debits—The term "debit" relates to the basic accounting equation of "assets equal liabilities and owners' equity (or fund balance)." Debits, on one hand, increase assets or expenses, and, on the other hand, decrease revenues and owners' equity (or fund balance). The "debit" is the recording entry to the left column in the double-entry accounting records.

Debt—An obligation that results from the borrowing of money or from the purchase of goods and services.

Debt financing—Acquisition of an asset by borrowing money, thereby creating a liability. Typical forms of debt financing are loans and mortgages.

Debt service—All payments in connection with funds borrowed by an institution: principal payments, interest charges, payments to sinking funds to ensure future principal and interest payments, payments to reserves to ensure proper upkeep and maintenance of the facilities, trustees' service charges, legal expenses, and other items related to indebtedness.

Deferred charges—Expenditures that are not chargeable to a fiscal period in which they are needed but are carried on the asset side of the balance sheet pending amortization or other disposition.

Deferred (or unearned) revenue—That portion of receipts for which services have not been completely performed such as food service payments. Until such services are performed in their entirety, that portion of the receipts is considered a liability.

Deficit—The excess of the liabilities and reserves of a fund over its assets. It is also the excess of expenditures over revenues during an accounting period.

Depreciation—Expiration in the service life of fixed assets other than that attributable to wear and tear, deterioration from physical elements, inadequacy, obsolescence, or waste of assets.

Designated funds—Unrestricted monies expendable only for purposes designated by the governing board.

Direct expenses—Those expenses that can be charged directly as a part of a cost of a product for service, of a department, or of an operating unit. They are to be distinguished from overhead and other indirect costs that must be prorated among several products or services, departments, or operating units.

Direct labor—The cost of labor directly expended in the production of specific goods for rendition of specific services.

Direct materials—The cost of materials that become an integral part of a specific manufactured product or that are consumed in the performance of a specific service.

Disbursements—Payment in cash.

Double-entry system—A system of bookkeeping that requires, for every entry made to the debit side of an account or accounts, an entry for a corresponding amount or amounts to the credit side of another account or accounts.

Effective interest rate—The rate of earning on a bond investment based on the actual price paid for the bond, the coupon rate, the maturity date, and the length of time between interest dates. This is in contrast to the nominal interest rate.

Encumbrances—Obligations in the form of purchase orders, contracts, or salary commitments that are chargeable to an appropriation and for which a part of the appropriation is reserved. They cease to be encumbrances when paid or when the actual liability is recorded.

Endowment funds—Funds that a donor or other outside agency has stipulated, as a condition of the gift, that the principal is to be maintained inviolate and in perpetuity and that only the income from the investments of the fund may be expended.

Endowment income—Yield, usually in the form of interest and dividends, that occurs as a result of investing the principal of an endowment fund. Capital gains and losses are not a part of endowment income.

Entry—The record of a financial transaction in its appropriate book of accounts. An entry is also defined as an act of recording a transaction in the books of account.

Expendable fund—A fund whose resources, including both principal and earnings, may be expended.

Expenditures—Where accounts are kept on the accrual or modified accrual basis, this term designates the cost of goods or services received, whether or not payment has been made. Expenditures also include provision for debt retirement not reported as a liability of the fund from which retired as well as capital outlay. Where accounts are kept on the cash basis, the term designates only actual cash disbursements for these purposes.

Expenses—Charges incurred—whether paid or unpaid—for operations, maintenance, interest, and other charges that are presumed to benefit the current fiscal period.

Face value—As applied to securities, the amount of liability stated in the security document.

Fidelity bond—A written promise to indemnify against losses from theft, defalcation, and misappropriation of funds.

Fiscal year—A twelve-month period of time to which the annual budget applies. At the end of this period an organization determines its financial position and the results of its operations.

Fixed assets—Assets of a long-term character that are intended to continue to be held or used such as land, buildings, machinery, furniture, and other equipment.

Fixed charges—Expenses, the amount of which are more or less fixed. Examples are such items as interest, insurance, and contributions to pension funds.

Floating debt—Liabilities other than bonded debt and time warrants that are payable on demand or at an early date.

Full-time equivalent (FTE)—A means for expressing part-time students, faculty, or employees in terms of full-time students, faculty, or employees. The formula for determining an FTE is generally based on credit hours. For example, an institution may define full time as being 12 credit hours. Thus a student (or faculty member) taking (or teaching) 3 credit hours would be a .25 FTE. The same applies to staff based on the number of hours in the normal work week for the job.

Fund—An independent fiscal and accounting entity with a self-balancing set of accounts recording cash and/or other resources together with all related liabilities, obligations, reserves, and equities that are segregated for the purpose of carrying on specific activities or attaining certain objectives in accordance with specific regulations, restrictions, or limitations.

Fund accounting—A sum of money and other assets that constitute a separate accounting entity, created and maintained for a particular purpose and having transactions subject to legal or administrative limitations. Its double-entry accounts are self-balancing, and from there a balance sheet and operating statement may be prepared.

Fund balance—The excess of the assets of a fund over its liabilities and reserves. An exception is in a case of a fund subject to budgetary accounting prior to the end of a fiscal period. In this instance a fund balance is the excess of the fund's assets and estimated revenues for the period over its liabilities, reserves, and appropriations for the period.

General fund—A fund used to account for all transactions of an organizational unit that are not accounted for in another fund.

General ledger—A book, file, or other device that contains the account needed to reflect, in summary and in detail, financial position and result of financial operations.

Grant—A contribution by one unit to another unit. The contribution is usually made to aid in the support of a specified function, but is sometimes also for general purposes.

Indirect costs—Costs that have been incurred for purposes common to some or all of the specific programs or activities of an institution but that cannot easily be identified and charged directly to them with a reasonable degree of accuracy and without an inordinate amount of accounting. Examples include such items as heating, lighting, air conditioning, and janitorial services of buildings plus administrative services such as accounting, purchasing, personnel, and library services.

Internal auditing—A review of operations within established policy guidelines that provides managers with reports, conclusions, and recommendations of the results of the review. It is used to measure and evaluate the effectiveness of the organization.

Internal control—A plan whereby employees' duties are arranged and records and procedures are designed in a way that permits effective accounting control over assets, liabilities, revenues, and expenditures. Under such a system the work of employees is subdivided so that no single employee performs a complete cycle of operations. Thus, for example, an employee handling cash would not post accounts receivable records. Under such a system the procedures to be followed are delineated and require proper authorization by designated officials in order for all actions to be taken.

Inventory—A detailed list showing quantities, descriptions, and values of property and, frequently, units of measure and unit prices.

Investments—Securities and real estate held to produce income in the form of interest, dividends, rentals, or lease payments.

Journal voucher—A voucher for recording certain transactions or information in place of or supplementary to the journals or registers. The journal voucher usually contains an entry or entries, explanations, references to documentary evidence supporting the entry or entries, and the signature or initials of one or more properly authorized officials.

Land—A fixed asset account that reflects the value of land owned by an organization. If land is purchased, this account shows the purchase price and costs such as legal fees and excavation costs incurred to ready the land for its intended use. If the land is acquired by gift, the account reflects the proposed value at the time of acquisition.

Leasehold—The right to the use of real estate by virtue of lease, usually for a specific term of years, for which a consideration is paid.

Liabilities—Debt or other legal obligations arising out of past transactions that must be liquidated, renewed, or refunded at some future date.

Life income agreement—An agreement by which a donor makes assets available to an institution under the condition that the institution will, for the donor's lifetime, pay the donor the income earned by the assets.

Life income funds—Funds acquired by an institution subject to life income agreements.

Loan funds—Funds to be lent to students, faculty, or staff. When both principal and interest on the loans are lendable, they are included in the loan funds group. If only the income from a fund is lendable, the principal is included in the endowment and similar funds group. The cumulative income, however, constitutes the loan fund.

Long-term debt—Debt with a maturity of more than one year after the date of issuance.

Maintenance—The upkeep required on physical properties to make them fit for use or occupancy. Examples are inspecting equipment to detect defects and making repairs.

Mandatory transfers—Transfers arising out of binding legal agreements related to the financing of the educational plant such as amounts for debt retirement, interest, and required provisions for plant renewals and replacements that are not financed from other sources. Also, transfers arising out of grant agreements with federal government agencies, donors, and other organizations to match gifts and grants to loan funds or other funds.

Net income—The term used in accounting for designating the excess of total revenues over total expenditures for an accounting period.

Net revenue available for debt service—Gross operating revenues of an enterprise less operating and maintenance expenses but exclusive of depreciation and bond interest.

Nominal interest rate—The contractual interest rate shown on the face and in the body of a bond that represents the amount of interest to be paid. This is in contrast to the effective interest rate.

Nonoperating expenses—Expenses incurred for nonoperating properties, or expenses incurred in performing activities not directly related to supplying the basic service of an enterprise.

Notes payable—Generally, an unconditional written promise signed by the maker to pay a certain sum in money. The money is payable on demand or at a fixed or determinable time either to the bearer or to the order of a person designated on the note.

Object classification—Grouping expenditures on the basis of goods or services purchased. For example, expenditures would be grouped under personal services, materials, supplies, equipment, etc.

Obsolescence—The decrease in the value of fixed assets relating to economic, social, technological, or legal changes.

Operating budget—A budget that applies to all outlays except capital outlays.

Operating statements—A statement that summarizes the financial operations for an accounting period. This is to be contrasted with a balance sheet that shows financial position at a given time.

Original cost—The total of assets given and/or liabilities assumed to acquire an asset.

Overhead—Those elements of cost necessary to produce an article or to perform a service that cannot be easily or accurately charged to the product or service. Overhead items usually relate to those objects of expenditure that do not become an integral part of the finished product or service. Examples are rent, heat, light, office supplies, and insurance.

Perpetual inventory—A system in which the inventory of units of property at any date may be obtained directly from the records without resorting to an actual physical count.

Petty cash—A sum of money set aside for the purpose of making change or paying small obligations. The money is used for cases in which issuing a formal voucher and check would be too expensive and time consuming.

Plant funds—Funds to be used for the construction, rehabilitation, and acquisition of physical properties for institutional purposes; funds already expended for such properties; funds set aside for the renewal and replacement of properties; and funds accumulated for the retirement of indebtedness on these properties.

Prepaid expenses—Expenses entered in the accounts for benefits not yet received.

Prepaid expenses differ from deferred charges in that they are spread over a shorter period of time and are regularly recurring costs of operations. Examples of prepaid expenses are prepaid rent, prepaid interest, and premiums on unexpired insurance.

Pro forma—A term used in conjunction with a noun to denote a sample form, document, statement, certificate, or presentation. The contents may be either wholly or partially hypothetical or factual and may be estimates or proposals.

Program budget—A budget in which expenditures are based primarily on programs of work and secondarily on character and object budget. A program budget is a traditional type of budget that falls between the traditional character and object budget, on one hand, and the performance budget, on the other.

Project—A plan of work, job, assignment, or task.

Purchase order—A document that authorizes the delivery of specified merchandise or the rendering of certain services and the making of a charge for them.

Quasi-endowment funds—Funds that the governing board, rather than a donor or other outside agency, has determined are to be retained and invested. The governing board has the right to decide at any time to expend such funds. These monies are sometimes referred to as funds functioning as endowment.

Receipts—A term that, unless otherwise qualified, means cash received.

Recoverable expenditures—An expenditure made for or on behalf of another fund—or for a private individual, firm, or corporation—that will subsequently be recovered in cash or its equivalent.

Refund—An amount paid back or credit allowed because of an overcollection or due to the return of an object sold.

Reimbursement—Cash or other assets paid back for work or services performed; repayment for expenditures made for or on behalf of another individual, firm, or corporation.

Replacement cost—The cost, as of a certain date, of a structure that can render similar service—but need not be of the same structural form—as the structure to be replaced.

Requisition—A written demand or request, usually from one department to the purchasing officer or from one department to another department, for a specified article or services.

Reserve—An account that records a portion of the fund balance that is allocated or set aside for some future use and is thus not otherwise available.

Resources—The actual assets of an entity, such as cash, land, and buildings plus contingent assets such as estimated revenue applying to current fiscal year not accrued or collected.

Restricted funds—Funds limited to a specific use by outside agencies or persons. These are to be distinguished from funds over which the institution has complete control or freedom of use.

Retained earnings—The accumulated earnings of an enterprise that have been retained in the fund and that are not reserved for any specific purpose.

Schedules—The explanatory or supplementary statements that accompany the balance sheet or other principal statements that are periodically prepared from the accounting records.

Securities—Bonds, notes, mortgages, or other forms of negotiable or nonnegotiable instruments.

Short-term debt—Debt that matures one year or less after the date of issuance.

Sinking fund--Cash or other assets, and the interest or other income earned from it, that are set apart for the retirement of a debt or for the protection of an investment in depreciable property.

Spending policy—In investing for total return, the portion of earnings allocated for current operating purposes. It is expressed as a percentage of market value and is sometimes called the "pay-out rate." The term "earnings" includes the sum of net realized and unrealized appreciation or shrinkage in portfolio value plus dividend and interest income. A prudent spending policy would protect the endowment from loss of purchasing power before appropriating gains.

Standard costs—A predetermined cost of performing an operation efficiently under reasonable and normal conditions. Normal conditions exist when there is an absence of extraordinary factors affecting the quality or quantity of the work performed, or the time or method of performing it.

Stores—Goods on hand in storerooms, subject to requisition and use.

Surplus—See fund balance or retained earnings.

Suspense account—An account that carries charges or credits temporarily, pending the determination of the proper account or accounts to which they are to be posted.

Temporary loans—Short-term obligations representing amounts borrowed for a short period of time and usually evidenced by notes payable or warrants payable. They may be unsecured or secured by specific revenues to be collected.

Term endowment—Funds which donors or other outside agencies have contributed to an institution with certain terms or conditions attached and that, only upon the occurrence of a particular event or upon passage of a stipulated date, can be expended.

Total return—The sum of net realized and unrealized appreciation or shrinkage in portfolio value plus yield (dividend and interest income).

Transfers—The moving of assets, liabilities, and balances from one fund group to another.

Trial balance—A list of the balances of the accounts in a ledger kept by double entry with the debit and credit balances shown in separate columns. The totals of the debit and credit columns are equal.

Unappropriated budget surplus—If the fund balance at the close of the preceding year is not included in the annual budget, the term designates that portion of the current fiscal year's estimated revenues that has not been appropriated. If the fund balance of the preceding year is included, the term designates the estimated fund balance at the end of the current fiscal year.

Undesignated funds—Unrestricted monies available for any purpose.

Unearned or deferred revenue—See deferred or unearned revenue.

Unencumbered appropriations—That portion of an appropriation not yet expended or encumbered.

Unit cost—A term used in cost accounting to denote the cost of producing a unit of product or rendering a unit of service.

Unrestricted funds—Monies provided to the institution with no restrictions on their use.

Voucher—A written document that evidences the propriety of transactions and usually indicates the accounts in which they are to be recorded.

Work in process—The cost of partially completed products manufactured or processed. An example would be a partially completed printing job. This term is sometimes referred to as "work in progress."

Work order—A written order, authorizing and directing a certain task to be performed, that is issued to the person who will direct the work. Among the items of information shown on the order are the nature and location of the job, specifications of the work to be performed, and a job number that is referred to in reporting the amount of labor, materials, and overhead.

Work unit—A fixed quantity that will consistently measure work effort expended in the performance of an activity or in the production of a commodity.

Working capital—Current fund cash, or current fund assets converted to cash, that will be used to liquidate current fund liabilities in a normal operating cycle—typically one year.

PART III

MAINTENANCE MANAGEMENT

PART III: CONTENTS

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INTRODUCTION

Changing Maintenance Needs

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During the last 20 years several factors have evolved that make maintenance of university and college buildings and equipment not only more important but much more expensive. These factors include higher technology and mechanization; more complex equipment; increased inventories of parts and supplies; higher quality requirements; the ever-increasing cost of energy, labor, and materials; and the obligation to comply with governmental regulations mandated by the Office of Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA), the Department of Energy (DOE), and the Department of Education (ED). Skilled maintenance people are more difficult to hire or to keep after they are trained, and the employment of unskilled people results in overstaffing, lower quality, and higher costs.

There is a critical need for state legislators, regents, boards of trustees, chancellors, presidents, and vice-presidents to be knowledgeable and concerned about the maintenance management needs of postsecondary education facilities. The primary interest of higher administration is to reach the "Excellence in Education" goals of their institutions. Many view maintenance of facilities as a necessary evil that must be tolerated in the pursuit of their academic goals. Even within the ranks of physical plant administrators there are many who share the opinion that improvements in maintenance management are a lost cause and that it is not worth the effort to attempt to improve them.

Contrary to this thinking, maintenance improvements are not a lost cause—maintenance work like production work can be measured, controlled, and its effectiveness improved.

Due to the lack of knowledge—and sometimes complacent attitudes—of administrators toward maintenance management, the physical plant administrator must be the initiator and driving force that develops, implements, and maintains an effective management program. This program must provide the institution with the most efficient maintenance programs possible. Plant administrators and their staffs must be able to demonstrate their management abilities to derive maximum benefits from available resources. Therefore, the purpose of this part of *Facilities Management* is to present the best thinking available to help physical plant administrators, both the veterans and the fledglings, develop maintenance management programs tailored specifically for their campus.

Maintenance management can be defined as the systematic and effective management of a maintenance activity in which sound applications are made of the three basic elements of scientific management—organization, measurement, and control. The outline for this part was specifically developed to incorporate those three basic elements throughout the discussions. For the purpose of this book, maintenance management covers all activities for which the classic physical plant organization is normally responsible. This includes building and equipment maintenance and repairs, minor construction, renovations, alterations, custodial services, and grounds maintenance.

The authors and reviewers of the following chapters are professionals in the field, both technically and managerially. And this work represents the culmination of many years of experience in maintenance management of facilities, including higher education and industry. Each author presents management methods and procedures that have proven to be effective. Although the authors have purposely avoided the at-our-school syndrome in the text of their writing, many of the management systems are illustrated by the use of actual examples and forms as appropriate. The management concepts presented are applicable regardless of the institution's size, location, or types of facilities and equipment being maintained.

While it is certainly beneficial, today's successful plant administrators do not have to be engineers. But they must be planners, organizers, measurers, analyzers, controllers, motivators, innovators, and doers. The chapters that follow cover the scope of Maintenance Management and suggest basic concepts that, if practiced, will ensure the efficient and economical management of a physical plant's maintenance responsibilities.

CHAPTER 1

Overview of Maintenance Management

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1.1 GENERAL

The five essential management functions are planning, organizing, staffing, controlling, and directing.[1] The discussions of maintenance management in the following chapters will be concerned with the application of these five functions to physical plant maintenance and operations—a necessary and extremely important component in all education activities.

Maintenance management in colleges and universities has evolved rapidly over the past two decades, reflecting a change in attitude toward the maintenance task by top level administrators and managers. The maintenance function had little importance at many institutions when the facilities were constructed with lavish government spending programs and private endowments. Now it has become apparent that the plant must be maintained if it is to continue to provide the kind of service and environment needed for quality education programs in a safe and healthy setting.

Plant expense is also a source of growing concern to educators, legislators, and others. The expense is exacerbated by the rapidly escalating cost of energy, which has focused attention on the heavy impact facilities have on monies available for educational programs. With the cost of utilities for education institutions tripling since 1965-66, physical plant budgets now represent an estimated 11 percent of the total general and educational expenses of colleges and universities throughout the United States.[2] This level of expense warrants priority attention and as a consequence, the discipline of maintenance management, pioneered in industry and embraced by federal agencies, is finally receiving the emphasis in higher education that it has long deserved.

Equally important to this changed attitude toward maintenance is the increasing awareness that the cost of deferred maintenance—required repair and modernization work on the plant that has been delayed by inadequate budgets, especially during the past 20 years—has now exceeded $35 billion[3] (some authorities estimate $50 billion[4]) and is climbing at an exponential rate. Expenses and potential expenses of this magnitude demand the ultimate in good management techniques to control their growth and eliminate waste.

Objectives and Scope

The basic objectives of maintenance management are to provide the climate, organization, leadership, training, procedures, resources, and judgment that will allow the maintenance function to provide necessary maintenance and repair services to the plant. These services ensure the plant's continued use and protection; afford a safe, secure, healthful, and enriching environment for students, faculty, and staff; and enhance the appearance of and service to the community in which the institution is located, while being as cost effective as possible.

Essential elements of these objectives are—

- Reduction of facility depreciation.
- A reduced rate of equipment and structural failures.
- Lower maintenance costs.
- An effective and efficient organizational structure.
- An experienced, well-trained, and motivated staff.
- Improved planning and scheduling of work.
- Management of resources to eliminate waste while providing needed materials, parts, tools, and equipment.
- A control system that regulates, accomplishes, and accommodates the measurement of maintenance activity.

The scope of Part III, Maintenance Management, ranges from the definition of management systems to the use of computers in the application of these systems. Current preventive maintenance practice is described, as well as methods for documenting and programming deferred maintenance. The importance of coordination, planning, and prescheduling of work in nearly all maintenance activity is emphasized—even for such traditionally routine or repetitive service functions as grounds and custodial maintenance. Another section of the text discusses materials management, recognizing the importance of an area of expense that ranges from 15 to 20 percent of the average physical plant maintenance budget.

Benefits

An effective maintenance management program can provide meaningful benefits to an education institution, in spite of the difficulties in assessing the value of such efforts in dollars and cents. Plant maintenance in learning and research institutions does not lend itself to the profit/loss analysis of industry (particularly production line industry). There the manufacture of tangible goods precisely determines the actual worth of the maintenance activity.

The intangible benefits of an improved environment, student and faculty morale, user comfort and convenience, personnel safety and security, and community pride that are generated by well-maintained, aesthetically pleasing campus facilities should not be minimized because they cannot be quantified. They all contribute significantly to the effectiveness of any education program. Well-maintained facilities allow the institution to satisfy its teaching and research objectives to a greater extent than would be possible in a rundown, hazardous, insecure, and unattractive facility of which no one could be proud.

As for more tangible results or expectations from the application of modern maintenance management techniques, a conservative estimate of time lost in an average maintenance organization due to coordination is approximately one-third of the net working day, of which 40 or 50 percent can be saved by the use of good management.[5] Another authority suggests that 20 percent savings have been demonstrated in industry and government installations by applications of planning, scheduling, and work measurement.[6] Yet another rule of thumb is that for every dollar expended in good planning, at least five dollars will be saved in maintenance expense.[7]

A good maintenance management program can improve productivity, reduce the number of personnel required to perform a given workload, and improve the level of maintenance. The higher level of maintenance will in turn reduce the frequency of equipment and system failures and the required overtime to repair, as well as reduce waste in material, equipment, and tool purchases. A well-maintained plant will use less energy, will require less effort to keep clean, and will experience a slower rate of deterioration. This affords a greater degree of protection to the capital investment. Effective maintenance management is good business.

1.2 RESPONSIBILITIES FOR MAINTENANCE MANAGEMENT

Generally the responsibility for upkeep of the physical plant in colleges and universities rests with the senior administrative officer who carries a wide variety of titles including Vice President for Administration, Administrative Vice Chancellor, Vice Chancellor–Administrative Affairs, Executive Dean, Business Manager, Vice President for Business Affairs, Associate Vice President–Facility Planning and Operations, etc.

The more direct responsibility for maintenance management usually resides with a physical plant administrator bearing a title such as Director of Physical Plant, Director of Buildings and Grounds, Director of Plant Operations and Maintenance, Director of Maintenance, Manager–Plant and Services, Superintendent–Buildings and Grounds, etc.

General Responsibilities

Maintenance management in a physical plant organization usually encompasses the following general responsibilities:

- Planning and scheduling of as much of the maintenance load as practicable.
- Establishing an efficient communication system for effective coordination and direction.
- Designing an organizational structure with clear lines of authority and grouping of related skills and equipment.
- Developing an effective training program for upgrading personnel.
- Developing a practical set of controls and procedures that allow the orderly, timely, and efficient accomplishment of required facilities work.
- Establishing a meaningful performance measurement system and a quality control function.
- Developing an annual budget that identifies required operating funds as well as adequate allowances for special repair requirements and deferred maintenance work.
- Actively recruiting a qualified and energetic work force.
- Maintaining a safe, secure, and accessible environment for all students, faculty, staff, and visitors to the campus.

Management Policies and Principles

The character and style of a maintenance organization are reflected in how it gets the job done. This is influenced—in large part—by the policies and principles adopted and adhered to by plant management.

Certainly a work approval system should be adopted (and published) that provides fair treatment to all clients with facilities requirements on the campus. A well-defined list of descending priority categories of work is necessary, combined with a formal definition of the differing classifications of work. Sometimes the classifications will include levels determined by monetary limits.

A typical priority definition system is outlined below:

Priority 1	Hazards to Life, Health, and Property Work required to provide or restore adequate security to a facility, to eliminate hazards to life or health (safety), or to protect valuable property.

Priority 2	Essential Support Work needed to accomplish the institution's primary objectives (teaching and research), to prevent a breakdown of essential operation or housekeeping functions, or to improve the operating performance of a necessary system.
Priority 3	New Programs Alterations or additions required to accommodate experimental programs, revised teaching approaches, added functions, or reorganizations.
Priority 4	Desirable Convenience and environmental improvement items not qualifying for higher priority.

A typical work classification system consists of the following categories:

Class	Abbreviation	Examples
Maintenance	Maint.	Checking, inspecting, servicing, adjusting, minor repairs, hardware replacement, repainting, patching, sealing, random tile replacement, cleaning, cleanup, pruning, trimming, treating, applying, fertilizing, scarifying, mowing, etc.
Repair	Rep.	Repair or replacement of obsolete, worn, broken, failed, or inoperative systems or components. Restoration, rehabilitation, reglazing, etc.
Alteration	Alt.	Modification, expansion, change in configuration or capacity, modernization.
Minor Construction	MC	New work, addition, extension, erection.
Installation	Inst.	New equipment or systems in or on an existing structure, facility, or property.
Fabrication	Fab.	Assembly or manufacture of furniture, shelving, bulletin boards, pinboard, signs, sash, picture frames, etc. Includes installation when appropriate.
Delivery/ Pick-up	Deliv.	Movable items such as plants, shrubs, bleachers, carnival booths, platforms, furniture, books, equipment, etc.
Loading/ Unloading	Load	Material, furniture, equipment, etc.
Demolition	Demo.	Disconnect, strip, cannibalize, salvage, remove, destroy, raze, tear down. Includes hauling to appropriate disposal point.

A policy on level of effort or maintenance standards should also be adopted that specifies the frequency of maintenance or repair. A standard on the quality of materials to be used sometimes helps define the expectations of clients, as well.

Other principles of good management to recognize and adhere to in the organization structure include:

- Limiting span of control.
- Grouping similar skills, tasks, equipment, and material usage.
- Establishing a control function separate from the actual operating functions.
- Never structuring an organization around individual talents and capabilities if it can possibly be helped.

One of the guiding precepts of maintenance work is to do it as effectively and as cheaply as possible while maintaining a consistently high level of quality. If costs of certain kinds of work by the maintenance force or materials, utilities, and equipment controlled by the maintenance organization are to be charged back to any clients, a clear and concise policy on chargeback must be published and carefully followed.

These are only a few of the more important policies and principles that a well-managed plant function should cultivate. There are many of lesser importance or with only limited application because of campus peculiarities.

Maintenance Engineering

A number of tasks in maintenance management benefit from the technical knowledge and analytical skills normally associated with an engineering discipline. A full-time employee for these tasks can be afforded only by larger organizations. But even part-time application of maintenance engineering by an overseer can be valuable to the modern maintenance activity.

The following elements of a good maintenance management program are the maintenance engineer's responsibilities:

- Complete a facilities' inventory and condition survey.
- Compile an equipment inventory.
- Develop maintenance standards that define a level of effort showing expected frequency of key actions.
- Develop a five-year plan for special repairs incorporating all deferred maintenance and those repairs projected as requirements in future years.
- Create an equipment standardization program for greater redundancy in maintenance actions and reduced parts inventories.
- Develop materials standards and standardization to reduce stock inventories maintained and promote specialization of techniques

used for maintaining, restoring, and improving the quality of facilities while reducing failure frequencies.

- Perform maintainability assessment on all new construction designs and equipment proposals.
- Evaluate new ideas concerning materials, equipment, procedures, etc.
- Develop or select appropriate time standards for a work measurement program.
- Develop or promote adequate training programs for equipment or building features that exist or are planned for installation on campus.
- Develop and conduct a performance analysis program including periodic reporting.
- Establish failure analysis for installed electromechanical equipment, vehicles, construction equipment, etc.
- Evaluate planned equipment overhauls for unforeseen problems.
- Implement warranty analysis and exercise when appropriate.
- Establish work methods analysis and productivity improvement.
- Evaluate preventive maintenance actions and frequency of application.

As this listing indicates, the discipline of maintenance engineering draws heavily on what could be construed as industrial, mechanical, electrical, or other specific fields of engineering. In reality, it is the application of engineering techniques to the maintenance function with its own diverse and unique problems and concerns.

Planning and Scheduling

Probably no other function characterizes the modern approach to maintenance better, or has had a greater impact on the improved efficiency and effectiveness of maintenance activity, than that of work planning and scheduling—or work control. A maintenance organization makes a significant change for the better when it starts preplanning jobs and scheduling from a central office by specialists, and stops relying on the shop foreman or supervisor to decide what work to do today and to chase materials and equipment.

The work control function is generally responsible for the following tasks:

- Receipt of work requests following a formal procedure for work definition, priority setting, and approval.
- Compliance with a maintenance plan and a preventive maintenance program in its scheduling activities.

- Operation of a service call or minor emergency response system.
- Planning all work involving more than a determined number of workhours, and excluding that work which can be categorized as routine maintenance, such as preventive maintenance, service calls, periodic servicing.
- Preparation of advance work schedules, usually on a weekly basis, and maintenance of a Master Schedule.
- Requisition of necessary materials and parts, and inventory control.
- Providing pertinent shop drawings, sketches, and work authorization documents to shop foremen.
- Maintaining progress status and cost data on all individual work requests and orders.
- Followup on jobs with elements (materials, workhours, equipment, access) that cause a variance from allotted schedule or that are predicted to do so.
- Maintaining an awareness of backlogs by shop or speciality.
- Evaluating work measurement and performance.
- Periodic reporting system of accomplishments by the work force.
- Maintaining vehicle and construction equipment status and scheduling maintenance and repair for this equipment.
- Maintenance of construction status and warranty information.

The primary objective of the modern maintenance organization is to reduce the involvement of first-line maintenance supervisors in the planning and scheduling process, thus allowing them to spend their time in the field overseeing the work actually being done. Shop or craft supervisors should spend 15 percent or less of actual work time on nonsupervisory tasks.[8] Organizing the maintenance function to provide central planning and scheduling can allow for the achievement of this goal.

Building Maintenance

Supervisors or managers of the building maintenance function maintain physical structures and their installed service systems and equipment such as plumbing, heating, ventilation, air conditioning, and electrical. These managers still have a sizable number of responsibilities that could be categorized as maintenance management, even though central planning and scheduling may relieve first-line supervisors or shop foremen of those management tasks.

In smaller organizations building maintenance managers may be assigned many of the responsibilities of maintenance engineering. These managers are responsible for helping develop an adequate budget and ensuring that funds are expended as wisely as possible. This requires the continuing assessment of work routines, techniques, material applications, and facility conditions before and after maintenance or repair is performed.

Other management tasks of building maintenance involve establishing—

- An adequate work inspection system.
- A viable preventive maintenance program that is adhered to religiously.
- Adequate stock levels of critical or much-used parts, materials, subassemblies, tools, etc.
- Effective emergency response plans.
- Good employee relations.
- Worthwhile training programs.
- A system that identifies safety hazards, security compromises, and property damage and ensures their correction at an early date.

The manager or supervisor is also involved in make-or-buy decisions for new parts or components, whether to contract work, or to use the in-house work force. He or she also has a strong voice in fitting jobs to the capabilities of specific individuals in the work assignment process. Finally this leader has a responsibility to participate actively in the scheduling process, explaining to work control—or the scheduling function—when something planned is impractical because of factors not apparent to the planner(s) or scheduler(s).

Utilities

The maintenance management responsibilities of the supervisor of utilities correspond closely to those of the managers of building maintenance. Certain other peculiar management responsibilities may apply, and they are usually determined by where the institution obtains its utilities. If purchased from an off-campus producer such as a public or private utility company, maintenance responsibilities are not as great as when utilities are generated on campus using in-house labor and owned facilities.

The unique management responsibilities of the utilities function include—

- Maintaining a current awareness of safety codes, operating requirements and licensing regulations, and ensuring compliance.
- Designing and promoting campus-wide energy conservation practices.
- Establishing utility consumption patterns, and altering operations and usage to coincide with less expensive rate structures.
- Studying and developing more favorable utility contracts for the institution.

- Adhering to and accomplishing timely compliance with regulations of the Occupational Safety and Health Agency, Environmental Protection Agency, and other regulatory agencies.

Grounds Maintenance

Grounds maintenance on campus is carried out in a public, fishbowl-like atmosphere. Every mistake or lack of adequate maintenance is seen by many people. This open environment and the influence campus appearance has on student morale and community pride, coupled with the necessity to assign grounds maintenance personnel to widely scattered areas of the campus on a given day, requires astute field supervision and good management practices.

Traditionally grounds maintenance has been conducted independent of the rest of the physical plant operation. It is often considered last when establishing a work control system featuring centralized planning and scheduling of work. This happens even though grounds maintenance can benefit as much from improved coordination, advance planning, and resource management as any other function. The grounds maintenance supervisor should be included in all periodic scheduling meetings and the work control section should expect input from grounds maintenance on a regular basis. The management tasks mentioned in Building Maintenance above also apply to the grounds function.

Grounds maintenance is relatively labor intensive and requires supervisors to be alert to labor saving ideas in material, tool, and equipment applications. Seasonal changes and field usage are most important to grounds management. A detailed master schedule of maintenance activities must be developed, kept current, and adhered to.

Compliance with a wide variety of federal, state, and local health and safety regulations is characteristic of grounds maintenance. A control system that outlines requirements and ensures compliance is especially helpful in the storage and application of pesticides and other controlled chemicals. Grounds maintenance workers are exposed to more hazards than other workers in the plant and usually have a higher incidence of injury accidents. This reason alone makes an effective safety program most important. A periodic certification program that stresses safe use of the equipment is also instrumental in reducing accidents.

The grounds maintenance supervisor should review landscape plans for new construction projects and campus renovation jobs to assure reasonable maintainability. Also, he or she must use good judgment in purchasing large lots of bagged and bulk materials and ensuring that they are stored and controlled properly (materials management).

Custodial Services

The nature of the custodial function is such that managers must have good people-handling skills above all else. The most labor intensive of all maintenance responsibilities, custodial service, requires the repeated accomplishments of a limited number of cleaning tasks. The skills required are readily found, thus the pay scale is traditionally lower than any other maintenance discipline.

Some people find completing a simple task repeatedly, knowing it will have to be done again soon, frustrating and unsatisfying. This dissatisfaction precipitates a higher degree of personnel problems that manifest themselves in high absenteeism, a larger number of discipline cases, frequent evidence of shoddy or marginal work, chronic tardiness, insubordination, quarreling among employees, rumor mongering, high turnover rates, and on and on. Motivating a work force with these kinds of built-in characteristics becomes the primary management concern.

Much custodial work must be done when a room or building is unoccupied (even though there is an increasing trend toward daytime shifts and better scheduling). This adds to the problem of good supervision, because the custodial force is widely dispersed during routine operations. Continuous field supervision is a necessity for the custodial force that meets its cleaning objectives. Central planning and scheduling and other maintenance management tasks described in Maintenance Engineering and Building Maintenance are required in the custodial function as well.

The need for improved management techniques in this area has been documented repeatedly, as well as the significant monetary savings available to education institutions.[9] Any function that costs from 20 percent to 40 percent of the physical plant budget—of which personnel expense composes some 95 percent of that cost—is certainly a fertile area for applying good management principles.

Some proven techniques include—

- Developing a level of effort or cleanliness standards.
- Conducting a facility inventory from a custodial viewpoint, to define the job required.
- Using time standards to determine the resources required to do the job.
- Maintaining a current schedule of room/area usage.
- Organizing the custodial force so that field operations can be completed efficiently under adequate supervision.
- Developing and conducting an effective training program.
- Developing a master schedule in coordination with the work control center.

- Establishing a periodic maintenance program (and adhering to it) for those tasks not required on a daily basis.

These and many other techniques will be discussed in detail in Chapter 7.

1.3 ORGANIZATION AND PERSONNEL

Basic to maintenance managers' needs in doing their jobs is an organizational structure that allows for accomplishment of plant maintenance requirements in an efficient and effective manner. Of course, the finest organizational design in the world will not satisfy this requirement by itself. The organization must employ workers who demonstrate a sufficient level of skill, experience, energy, and conscience, and in numbers and total capability consistent with the characteristic workload of the plant.

Following is a description of various organizational structures used in maintenance work and a discussion of the more important factors to consider when developing an organization scheme. Also included are criteria for determining what constitutes an appropriate work force in numbers, skill levels, and supervisory ratios.

Types of Maintenance Organizations

Facility maintenance activities have found their way, by design or chance, into a more or less structured discipline of responding/directing relationships. These relationships can be categorized as centralized organizations, de-centralized or area organizations, functional organizations, or a variation of these. The three schemes are defined as follows:

- Centralized or Shop. This organizational type relies on one central location, such as a corporation yard or shop compound, from which crews are dispatched to conduct maintenance of a facility. Usually this structure segregates the various craft disciplines into specific shops with their own supervisor or foreman. This has been the most popular organizational scheme for conducting facility maintenance on college and university campuses.
- Decentralized or Area. The campus is divided into geographical zones and all, or a significant amount, of the facility maintenance responsibilities in that area are assigned to a supervisor and a smaller team of craftsmen. These teams are usually made up of mechanics with various skills or specialties or in some cases with multiskilled individuals who accomplish a particular level of maintenance such as preventive, corrective, or renovation tasks.

Many times the area or zone teams are provided specialty work or heavy equipment help from a centralized cadre that supports all such organizational elements.

- Functional or Operational. This form tends to group responsibilities by type of major activity such as preventive maintenance, alterations and minor construction, equipment overhaul, installation work, window washing, renovation.

Most physical plant organizational structures are not pure forms of any one of the basic categories, relying on some aspects of the other categories to satisfy a peculiar requirement(s) in a more cost-effective manner.

In determining what constitutes the most practical organizational structure for a maintenance activity at a given physical plant, a number of factors should be considered:

- Physical layout of the campus.
- Condition of buildings, structures, and systems.
- Complexity of systems.
- Level of effort required to maintain plant adequately.
- Craft specialties that physical plant demands.
- Skill levels of available personnel.
- Existing organization structure of administrative and academic branches of institution.
- Location of shops and storage areas.
- Location of most critical campus systems or special problems.
- Travel time requirements.
- Communication systems available, their location, quality, and capability.
- Analysis of local craft union organizations, rules, contracts, and natural affiliations.
- Assessment of best time of day to perform specific tasks (determines work shifts).
- Availability and location of special-use equipment and personnel skilled in its operation.
- One building trade or skill's relation to another; their common reliance on the same skills, techniques, equipment, tools, or materials.
- Talent and skills of incumbent managers and supervisors.

The advantages of a centralized organization include—

- Consolidation of more supervision.
- Greater source of talent and experience to draw on in making work assignments.

- Easier dispatching of correct skill level and appropriate equipment and materials.
- More efficient pieces of equipment and numbers of skilled operators upon which to draw.
- Lesser impact of personnel absences (more flexibility in employee assignments and work load for a given day).
- More efficient use of emergency response personnel.
- Better training facilities and higher quality trainers.
- Greater demand for specialists, thus attracting more expertise.
- More efficient administration.
- Easier planning, scheduling, and coordination of effort.
- More convenient vehicle and shop equipment maintenance.
- Easier to determine job performance and status of projects.
- Easier to provide common direction and ensure its use.
- Improved security of resources.

The major disadvantages of a centralized organization are the increases in time required to transport personnel, materials, tools, and equipment to and from the job site, and a lesser degree of craftsman familiarity with the buildings/systems requiring work. This translates into—

- Increased response time on most emergencies.
- Lower productivity and quality of work, perhaps.
- Less "pride of ownership" and familiarity with facility details.
- Increased transportation/communication expense.
- Less effective field inspection of jobs.
- Lower awareness level of maintenance requirements.
- More time required for adequate job assessment (sometimes).

The decentralized or area concept of organization has not found widespread application in education institutions except at some of the large universities or those with geographically separated campuses, large dormitory complexes, or married student housing areas. The idea has merit in special situations to supplement a centralized or functional organization structure—in spite of the decided movement toward central planning, work control, and computerization—in the physical plant functions of colleges and universities.

Advantages of the decentralized maintenance organization include—

- Reduced timeloss due to travel.
- Faster response time on minor emergencies.
- Higher quality of work due to "pride of ownership" generated in workers familiar with buildings and systems and knowledge of their clients.
- Opportunity for greater worker productivity.

- Closer supervision and inspection of completed work.
- Greater sense of team effort by workers, inspiring closer cooperation.

Disadvantages of the decentralized organization include—

- Lowered management awareness of level of maintenance in plant.
- Diverse levels of maintenance between areas or zones.
- Poor supervision less obvious to management on a daily basis.
- Costly duplication of equipment, tools, materials.
- Less efficient utilization of equipment.
- Lowered levels of expertise in personnel.
- Personnel absences have greater impact on work schedule.
- Greater tendency to improvise, thus introducing safety hazards.
- Greater frequency of slack periods in service call operations.
- More administrative tasks levied on supervisor.
- Communications between field and office more difficult.
- Greater exposure to theft, vandalism, and misplacement of resources.

Variations of the functional organization concept have been used for years to apply specialized talent and emphasis to problem situations on college and university campuses. The rather limited geographical scope of most campuses favors a centralized organizational structure as the basic vehicle from which to work. John Heintzelman suggests that the purely functional organization would have distinct groups for "inspection, maintenance, repair, overhaul, construction, housekeeping, and salvage."[11] Plant organizations in postsecondary education have made some use of this concept to augment, temporarily or even permanently, what usually is a predominantly centralized organization. The concept applies to heavy industry and a production line environment much more readily than it does to the average campus.

In a climate where appreciation of the need for maintenance of existing facilities is growing, such as colleges and universities, the monies for capital improvements and enrollments are shrinking. Emphasis on major remodeling and contruction by in-house maintenance forces is declining, thus making the utilization of functional teams with these specialties less appropriate than in the past. One area may see a growing application of functional groups to augment a centralized organization. This is in the assignment of preventive maintenance and "find and fix" tasks to a multiskilled team of mechanics. The team continuously rotates through major campus buildings on a fixed schedule. Their efforts augment, and partially encompass, a computerized preventive maintenance program.

Equipment overhaul teams and renovation teams may become more popular in campus organizations as well, as emphasis on maintenance and repair increases in an era of diminishing budgets.

The following are advantages of a functional or operational organization:

- Efficient use of highly skilled specialists.
- Improved use of expensive tools and equipment.
- Efficient solutions to problems of life, health, and property hazards that may exist in campus buildings.
- Prompt correction or compliance with mandates from federal and state agencies.
- Needed alterations for new programs provided or support of reorganization within the institution.
- Money saved using in-house staff on a project rather than contracting the work.
- Increased efficiency and faster job completions through work repetition.

The disadvantages of a functional organization structure follow:

- Decline in maintenance on physical plant unless used for preventive maintenance only.
- Possible development of some jealousy and resentment between functional teams and other plant employees.
- Possible segregation of equipment in locations removed from needed areas.
- Draw-down of materials, equipment, tools, and vehicle levels on which the rest of the organization depends.
- Tendency toward isolationism and independent operations; ignoring of rules, regulations, and central policy.
- Weakened team spirit in whole organization as the functional team becomes more independent.
- Complications in logistics of communications.
- Less talent available for routine operations.
- Little time for training because of demands on functional team work.

These are some of the more pertinent arguments for and against the selection of a specific organizational structure. The inclination to focus on one pure form of organization invariably changes with time. Then it becomes evident that for improved effectiveness and productivity the average plant organization must be ever-changing in order to cope with new requirements of the plant, improving technologies, lower purchasing power, and changing capabilities of the work force. A pure form of any of the three organizational schemes discussed in this section will quickly be outdated in practice.

Basic Factors for Development of the Maintenance Organization

Most people have a desire to be productive and to spend their work time doing something worthwhile. To make this effort as valuable and efficient as possible, activities must be organized so that individual workers receive necessary direction, instruction, assistance, material resources, and training in a timely manner with as little duplication and wasted effort as possible.

In establishing the appropriate organizational structure for satisfying these requirements, consider the following basic factors:

- Operational objectives of the maintenance activity.
- Cost considerations.
- Kind of personnel required to manage, supervise, and perform actual maintenance.
- Site or campus peculiarities with regard to locale, climate, geographical spread, prevailing architecture, size, physical condition, usage patterns.
- Procedures required to accomplish characteristic activities.
- Physical limitations set by law, policy, labor contract, or tradition.
- Skills and experience of personnel available for hire.

Management is responsible for designing an organizational structure and administering that organization in such a manner that every worker can be productive.

There are a myriad of organization principles that apply to just about any structured activity taking place on a sustained basis. Maintenance organizations are no exception. Following are some of the more important principles to consider when developing an organizational scheme.

- Lines of authority (and reporting) should be clear and distinct.
- Vertical lines of authority should be as short as possible.
- Like functions should be grouped together.
- Number of managers/supervisors are determined by the distinct sections identified.
- One position in every organization should be responsible for performance of an entire activity.
- Responsibilities of each unit should be defined in writing.
- Assigned responsibility must be accompanied by an appropriate degree of authority and should be levied at the lowest possible level.
- There is a practical limit on span of control or number of persons one individual can supervise. Under normal circumstances this should be limited to about 5 with up to 12 when work is repetitive and problems are few.

- Coordination between functions is a must and should be encouraged.
- Physical arrangement of facilities and limitations on use can affect organizational patterns.
- Staffing is decided by the volume of work to be done.
- Lines of communication should be simple and direct.
- In any successful maintenance activity no simple function can stand on its own. All units must rely on other units—at least part of the time—if the maintenance objectives are to be satisfied. Management should encourage these interactions as much as possible by designing an organizational scheme that makes coordination easy and fosters an attitude of teamwork.

The principles listed above can be used to ensure that a critical consideration is not overlooked in formulating a new organizational structure. To flesh out the organization's skeleton, however, a number of other factors should be acknowledged as well:

- Policies the maintenance organization is expected to follow.
- Relationship of maintenance organization to institution.
- Controls on amount and type of work to be done by maintenance activity.
- Desirable skills, experience, and characteristics of people to employ.
- Coordination and communication scheme.
- Procedure manual for maintenance activity.
- Basic work rules required by institution, labor contracts.
- Categorization of work by priority, workhours, response time, kind of work, dollar limits.
- Approval levels.
- Safety and security requirements.
- Campus activity schedules (to determine required shifts and operations).
- Availability of transportation and access to areas to be maintained.
- Peculiar aspects of plant that require special recognition in the maintenance organization.

When the foregoing principles and factors are considered in the development of a new—or the revitalization of an old—physical plant organization and sufficient time has elapsed to allow practical application, the chances of satisfying campus maintenance requirements increase significantly.

Staffing the Maintenance Functions

The modern maintenance organization increasingly relies on sophisticated management tools and techniques and advanced technology in materials, tools, and equipment applications. This dependence—which is an effort to counter the effects of fewer personnel, expanding responsibilities, more complex systems, and aging plants—requires greater selectivity in the people hired to perform plant maintenance. Gone are the days when specialists could be used on a narrow range of tasks, often waiting for an emergency to develop or new construction or alteration to be initiated, so they could "do their thing." Maintenance is an on-going process that rewards lapses with accelerated deterioration, increased failures of critical components, and lowered environmental quality.

Above all else employees of a maintenance-oriented activity must be conscientious and honest. The nature of much of the work requires that the individual mechanic or service person work independently, without benefit of close supervision. Neglecting to perform prescribed tasks on the recommended frequencies or in the accepted manner, while reporting the work as complete, can precipitate situations even worse than if a planned maintenance program had never been started. Plant maintenance employees must be reasonably intelligent, trainable, preferrably experienced, flexible, proud of the job they do, people-oriented, and immune to the distractions of a busy campus.

Maintenance managers and supervisors must be enlightened. The broad scope of the responsibilities of the plant maintenance function, the significant portion of the campus budget administered, and the complex elements used by the work force and management to obtain more cost-effective maintenance and operations make it imperative that maintenance leaders be highly trained, experienced, and business-oriented. Administrators and supervisors must be completely open to new ideas, able to analyze without bias, and less tradition-bound than their predecessors. Maintenance managers of institutions are relying more on management techniques and control methods developed in business and industry. Leaders must be aware of that changing technology. This highlights the need for regular training and exposure to new ideas for the maintenance function to remain cost-effective and successful.

Knowing what kind of people are needed and then hiring them are two different matters. Recruiting should be conducted with as much exposure as possible. Administrators should take time to fill vacancies, even doing without needed services, when the quality of applications does not meet the organization's needs. The idea of promoting only from within is a dangerous and outmoded philosophy. It is only effective in the maintenance organization that is certain it is the best and cannot improve.

Admittedly institutional plant maintenance does not usually have pay scales as high as business or industry. Job security, continuity, and fringe benefits must be emphasized to attract good employees. On college and university campuses the general atmosphere, cultural and educational opportunities are positive selling points. Being part of the educational process that provides an important and necessary service for the future welfare of the country, the world, and its citizenry is a worthwhile and satisfying endeavor.

Work Force Size Determining the number of people and appropriate skills necessary to do the plant maintenance job is not a definite science, and never will be, in spite of attempts over many years to develop precise formulas, standards, and guidelines.

Every facility is unique in structure and layout. Its maintenance requirements are further influenced by such factors as past treatment, correct usage, climatic conditions, geographic features. Coupled with this uniqueness is the fact that maintenance requirements change constantly as the plant ages, usage patterns vary, techniques and material applications improve, and educational programs change.

Guides reflecting average number of employees in a similar activity are useful in establishing the initial cadre in a new organization or in determining if an existing organizaion is clearly out of line in personnel resources. But the only effective way to arrive at the correct work force size is by actual application of the force together with a valid performance measurement system that can gauge the quality of the work being performed. If the maintenance force consistently gains on the backlog of work, the day will eventually come when the function can do an adequate job with fewer people. However, external forces have determined the work load and work force size more frequently than has the super-efficient maintenance organization working itself out of a job.

The most commonly used measure of relative work load in physical plant maintenance is gross square feet of space maintained. This is adjusted and refined in some cases by various factors, but the universal gauge is gross square feet. Many have tried to develop staffing standards based on this consideration. The Association of Physical Plant Administrators of Universities and Colleges has been the most influential source of such guides for college and university applications for many years. The *1978-1979 Comparative Costs and Staffing Report for Physical Plants of Colleges and Universities*[12] includes fitted curves representing equations derived from data obtained by surveying member campuses for the number of employees actually used in five functional areas. The curves are plotted against ordinate values representing full time equivalent (FTE) employees and abcissa values representing gross square feet (in millions). Values extracted from these curves as approximations are reflected below.

These mean values reflect a wide variety of climatic conditions, levels of maintenance, physical plant age—factors that can significantly skew the values in individual cases. Also note that the data does not readily reflect the changing trend to increased administration and decreased operatives as modern maintenance practices, with formal planning and work control for more efficient performance, are embraced by campuses.

A number of state governments have attempted to establish staffing standards for physical plant activities in universities and colleges. An excellent survey of the better-known standards is included as part of the APPA

Figure 1-1

Mean FTE Strength per Gross Square Feet

Function	1 Mil	2 Mil	4 Mil	8 Mil	Total Observations
Administration	6	9	14	22	330
Engineering	3	5	7	11	154
Building Maintenance	20	39	80	170	343
Custodial Services	43	90	180	370	332
Landscaping and Grounds	8	14	24	42	327
Utilities	8	13	23	42	251
	88	170	328	657	

publication, *Formula Budgeting: An Approach to Facilities Funding.*[13] Where these criteria can be related solely to gross square feet, the staffing values are included to provide a partial comparison with the values extracted from the APPA *1978-1979 Comparative Costs and Staffing Report* and reflected in Figure 1-2.

Bill Thomas in "Financing for Higher Education in Public Institutions in Texas" says "with a certainty of 99 percent, one could claim that—

> 1.0 FTE physical plant employee is required for every 10,000 gross square feet of building space, and 148 FTE physical plant employees are required for every 10,000 FTE student enrollment."[14]

Thomas also makes the point that smaller institutions must devote a certain basic amount of administrative effort to the physical plant function regardless of their size. That observation is reflected in the staffing standards for the administration function listed in the figures above where the numbers in the Million Gross Square Feet columns seem disproportionate to values cited for larger plants.

Staffing Administrative Functions The information summarized above provides some idea of personnel strengths for the campus maintenance function based on actual experience or state manpower standards. It does not provide insight into what constitutes an adequate planning/scheduling function in terms of numbers of personnel. The following discusses the size of the planning and scheduling or work control function.

Figure 1-2

Physical Plant Staffing Values

Function	**Gross Square Feet** **1 Mil**	**2 Mil**	**4 Mil**	**8 Mil**
Plant Administration				
Florida	11	17	26	43
California	7.2	11.4	15.8	24.6
Building and Equipment Maintenance				
California	24.4	43	80.3	154.6
Custodial Services				
Florida	90.9	180.7	361.5	723.1
Texas	71.4	142.8	285.6	571.2
Washington	60.3	120.5	240.5	481.1
Landscaping and Grounds				
Florida	28.1	51.3	99.7	195.5
Utilites				
California	9	13	21	41
Total Physical Plant FTE				
Colorado	–	–	320	–
Texas	100	200	400	800
Maryland (minimum)	100*	200	400	800
(optimum)	125*	250	500	1000

*Unadjusted; does not include personnel.

One of the most frequent questions asked in college and university plant maintenance circles is—When does it becomes practical to install formal planning and scheduling as a distinct function?

In general practice when a maintenance department exceeds 10 persons and more than two or three crafts, some planning, other than day-to-day assignments by foremen, can result in improved efficiency.[15] John Waligora states that when an organization has 12 mechanics or more a planner is justified.[16]

Numerous rules of thumb have evolved regarding the number of planners and schedulers a maintenance function requires to properly service and control the work force.

- The ratio of plant engineering craftsmen to planners and schedulers ranges between 20 to 1 and 40 to 1. One scheduler can normally handle the work of two to four planners.[17]
- Three people should be able to do enough planning to keep 100 craftsmen busy.[18]
- The number of maintenance hourly employees per maintenance staff planner is 46. (From a survey of 93 industries.)[19]
- Planner/estimator/scheduler staffing should be based on a ratio of 1 to 40 mechanics, planners/estimators on a ratio of 1 to 60 mechanics, and schedulers on a ratio of 1 to 100 mechanics.[20]
- One planner/estimator can support 25 to 30 craftsmen with planned and estimated work orders, provided he or she has no other duties.[21]

Admittedly most of these rules come from maintenance functions in industry, but campus physical plant maintenance is not so dissimilar that we should ignore the value of this empirical information.

Before dismissing the subject of work force size for the physical plant maintenance function, some kinds of guidance should probably be offered on how to determine if an existing organization has enough people to do the job. (This presupposes that management, organization, and procedures are adequate and only personnel numbers are in doubt.)

Two of the more obvious indicators, both of which can be established rather quickly, are the size of the backlog and the amount of overtime required.

Callaway and Buttery suggest that a 10- to 15-day backlog is healthy, but they acknowledge this will vary widely by workload and craft.[22] A suitable backlog for one shop may be as low as 10 to 15 days, whereas another specialty of fewer mechanics dealing in less critical requirements, may be able to function well with as much as a 30-day backlog.

An optimum level of overtime ranges from 3 to 8 percent of total work performed.[23] With lean-and-hungry staffing, this figure can grow to 12 to 15 percent. Borden Coulter suggests that a 3 to 5 percent overtime range is a practical goal in industrial maintenance.[24]

Effective maintenance manpower determinations rely on experience or historical reference, logic and judgment, and cut-and-try exercises as opposed to rigid standards and formulas. The various tables and rules of thumb presented in this section are general guides from which to refine the actual staffing numbers that a specific physical plant requires to perform adequate maintenance.

Supervisor/Mechanic Ratio There is a practical limit to the number of people one person can supervise. This differs by individual supervisor, of course, and will vary depending on the complexity or sensitivity of the work being done. A supervisor of laborers for instance, may be able to direct and control three to five times as many people as an electrical or mechanical foreman.

Over the years a number of rules or strongly held opinions have gained acceptance regarding the supervisor/mechanic ratio in maintenance activities. These opinions are based on the experience of individuals and have held true for a majority of cases. Some of them are offered as guides:

- Lewis says the supervisor/mechanic ratio should range *from* 1 to 10 *to* 1 to 15 at the first line of supervision depending on skills and geographic dispersal of job locations.[25]
- According to Calaway and Buttery the normal range is *from* 1 to 6 *to* 1 to 12 varying by craft and that the ratio of second-line supervisors to craftsmen ranges *from* 1 to 20 *to* 1 to 40.[26]
- Knight suggests that three to six persons are the optimum number that should report to another individual. However, he acknowledges that this can go as high as 10 to 12 when the amount of supervision needed is small or work supervised follows a general pattern.[27]
- A survey of 93 companies in the chemical and allied products industries by Albert Ramond and Associates in the mid-1970s indicated that they averaged nine hourly maintenance employees per maintenance supervisor.[28]
- Discussions held at a technical session of the National Plant Engineering and Maintenance Conference indicated that—

  One plant averaged 10 workers per foreman but the ratio was higher for carpenters, painters, and workers who spent all their time in the machine shop.

  One plant had four maintenance foreman and each one supervised 14 employees. Another indicated that a maintenance foreman would supervise at least 12 workers on a shift.

  In area maintenance one company had 1 supervisor for 12 to 13 workers.[29]

The ratio of mechanics to supervisors is diminishing as more technology is employed requiring fewer people. Organizational structures change more slowly than eroding personnel strengths, and management is reluctant to eliminate supervisors in place of craftsmen when expected to do more with fewer resources. Also, the more technical and skilled the work becomes with increasing emphasis on safety, security, health, and environmental concerns, the more direct involvement is required of the supervisor. This also reduces the number of workers he or she can supervise effectively because of time demands.

It is not uncommon for a troubled organization undergoing a management audit to have its flat-shaped organizational structure—with many people being supervised by a few—specified as the main reason for its less than satisfactory performance. Good supervision is a necessity in the physical plant maintenance field and the capability of the individual supervisors to handle their assigned responsibilities, especially with regard to span of control, should be a matter of continuing concern to astute managers.

Flexibility-Adaptability of the Organization

The physical plant maintenance function must be flexible and adaptable to succeed in the modern era of reduced budgets, shifting emphasis on energy consumption, expanded technology, lower personnel strength, and increasing scope of responsibilities.

Flexibility and adaptability both denote an ability to change. For the purposes of this discussion they will be differentiated by assuming flexibility is the ability to change directions rather quickly, once a course of action has been decided. While adaptability suggests the capacity to take on new or added responsibilities with only a minimum of lost motion.

Establishing flexibility in an organization ensures that the people who actually turn the wrench, operate the equipment, and push the broom are not overly concerned or restricted by the notion of crossing jurisdictional lines between trades, crafts, skills, or classifications. The maintenance worker functions in an isolated environment more than most other occupations, frequently finding minor problems not previously identified that require correction immediately to eliminate a safety, security, health hazard, or danger to property. It is much more efficient to have the person who finds it fix it before leaving the site, rather than causing additional trips by someone carrying another title. The only concern should be whether the correction can be made safely and properly without worsening the condition that already exists. The employees who exhibit this spirit of self-reliance generally are highly motivated, proud of their abilities, and not under any unusual pressures from their peers or local labor unions to adhere to a strict hands-off policy.

The kind of person who does this best is one with broad experience, multi-talents, a clear and logical mind, and who follows appropriate safety practices. He or she normally displays an inquiring nature and accepts changes in original direction with ease, not hesitating to voice a concern management or supervision may not be aware of.

Organizational flexibility is enhanced by—

- Maintaining centralized tool cribs where spares in good condition are always available.
- Employing capable operators in central equipment pools.
- Maintaining a number of ready back-up jobs for weekly schedules (or overscheduling by 10 percent) to keep the workers busy when unforeseen cancellations occur.

- Cross-training of personnel to provide necessary familiarity, knowledge, and special skills when key personnel are not available.
- Maintaining current files of design drawings, utility maps, condition survey files, etc.
- Being aware of current class schedules, planned events, contract status, existing warranties, etc.

The adaptability of an organization is characterized by its ability to roll with the punches when a new requirement is identified unexpectedly. It is the wherewithal to get on with the usual work load while coping with, or quickly marshalling the required resources to undertake, added demands of the institution.

In the adaptable organization a sizable portion of the work force and management must be open to new ideas, training oriented, and willing to experiment to find a better mousetrap. The chances of an organization being adaptable are improved by developing and implementing—

- Emergency response procedures for specific scenarios.
- Recall rosters for emergencies after normal work hours.
- Blanket purchase orders with local suppliers for rapid acquisition of needed parts, materials, tools on a hurry-up basis.
- Strong spirit of cooperation with institution personnel and purchasing functions.
- Reference library of leading technical and professional periodicals, books, manufacturer's brochures for maintaining knowledge of current developments.
- Effective and pertinent training programs.
- Good long range planning related to master plan of college or university.
- A capable emergency response or service call force composed of outstanding tradesmen, linked by radio-communication to a control center.

The most obvious means of attaining flexibility and adaptability is through hiring temporary personnel when the work load surges or special skills are required beyond the capability of the permanent work force. On-call purchased labor (contract), temporary hires, casual labor are terms applied to these kinds of workers. Their employment can effectively satisfy physical plant requirements. Besides the acquisition of added capability, temporary workers can be laid off when the workload or budget recedes with no continuing obligation, or the option not to call for service. Problems can arise in the permanent work force if the wages for the temporary employees are higher or if they are assigned to work normally done by permanent employees.

Most institutions operate with personnel regulations or policies that set a limit on the term of employment for a temporary worker (not obtained through a fixed-end contract), beyond which the worker automatically attains probationary status as a permanent employee. This can have serious budgetary consequences if not managed properly, but the concept is too valuable to ignore for the added flexibility and adaptability it affords.

The physical plant maintenance function that is flexible and adaptable operates with confidence that it can cope with any situation.

Typical Organizational Charts

The traditional responsibilities for the physical plant maintenance organization can be grouped under five general headings recognized by the APPA accounting classification system:[30]

- Physical Plant Administration.
- Building and Equipment Maintenance.
- Custodial Services.
- Utilities.
- Landscape and Grounds Maintenance.

These categories have demonstrated their applicability over many years and will continue to constitute the major functional divisions of most physical plant organizations. However, with a shift in emphasis to energy conservation, work planning and scheduling, and preventive maintenance, these new functions appear more frequently in organizational structures as maintenance managers.

No two organizational charts are ever the same. Even when forced into a standard mold by directive, the peculiarities of a campus, either in overall organization, physical features, manager bias, or personnel capabilities, will result in individual variations in practice if not in form. Additionally, there are related functions that, on occasion, are placed under the umbrella of the physical plant organization that lead to some interesting variations, as well. These include such things as student housing; purchasing, supply, and receiving; communications; mail and reproduction services; public safety; moving services; vehicle operation and maintenance; and master planning.

The utilities responsibility at individual institutions can vary widely in scope. Most campuses have a central heating plant. Some have their own water and sewage treatment facilities. Fewer yet generate their own power. These differences will be reflected in individual organizational charts.

With all of these opportunities for deviations from the norm, the publication of a "typical" organization chart is meaningful only if it is viewed as a general guide or skeleton around which an appropriate organization can be structured.

The charts presented reflect a blend of experience and exposure to organization structures for a variety of maintenance activities over many years. Distinguishing between a small, medium, and large organization for college and university campuses is fraught with hazards. Relationships between organizational shape and size can be described as a general guide for managers trying to determine how much "organization" they can afford. Certainly there is a practical limit to overhead expense in an organization. If the definitions based on gross square feet of buildings maintained and number of personnel assigned do not seem pertinent to a particular campus, plant administrators are encouraged to use their judgment in arriving at a suitable organizational chart.

The subsequent diagrams should stimulate thought and serve as a checklist so that a key function or relationship is not overlooked when developing an effective organization.

Small Maintenance Organization Figure 1-3 is a graphic representation of an idealized organization structure for a small physical plant department—less than 500,000 GSF and fewer than 80 employees.

It identifies the three basic functions of plant maintenance: Building Trades, Custodial Services, and Landscaping and Grounds. The chart also recognizes the necessity for the support functions of administration (secretary), supply, and drafting. The Boiler Plant block is shown dashed. This indicates an optional need dependent on how extensive the campus involvement is with producing its own utilities.

To provide more balance to the Building Trades section and a greater degree of specialization in the larger units of this category, the crafts have been segregated into structural and systems elements.

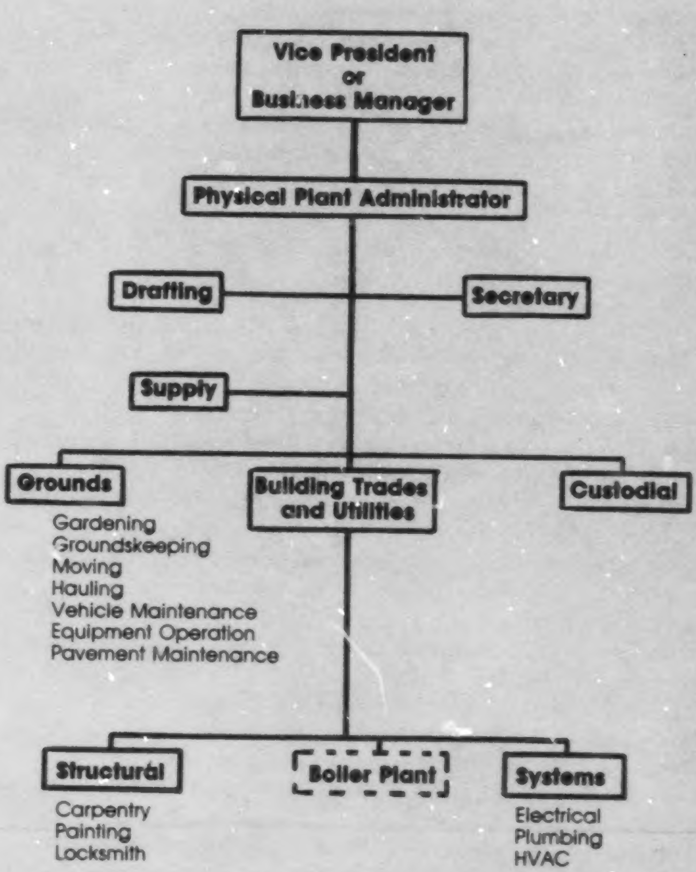
An organization of this size generally cannot support a full-time energy coordinator nor an engineer. We assume those responsibilities are handled or shared by the Chief or one of the section heads and augmented when necessary by outside services. The accounting responsibilities are only partially handled within the department. Planning and work control is normally done by the supervisors of the various sections.

Medium Size Maintenance Organization Figure 1-4 represents a medium-sized organization maintaining 500,000 to 2 million gross square feet and employing 85 to 200 people.

In contrast to the small organization described above, the medium-sized organization can usually afford a distinct planning and work control function, an energy coordinator, and perhaps a separate preventive maintenance team. Preventive maintenance is usually performed—on a formal basis—by all of the operating functions.

The administration section in this size organization—which provides some personnel, budget, accounting, and supply services—is usually more efficient than one that refers everything to a discrete function in another campus location.

Figure 1-3
Typical Small Maintenance Organization*


Vice President
or
Business Manager
Physical Plant Administrator
Drafting
Secretary
Supply
Grounds
Gardening
Groundskeeping
Moving
Hauling
Vehicle Maintenance
Equipment Operation
Pavement Maintenance
Building Trades and Utilities
Custodial
Structural
Carpentry
Painting
Locksmith
Boiler Plant
Systems
Electrical
Plumbing
HVAC

*Up to 500,000 GSF, less than 80 employees.

As maintenance organizations become larger their utilization of professional engineers becomes more common. It also becomes cost effective to have one or more engineers employed in-house. This presumes that adequate technical expertise is available to provide effective contract management and inspection, a full range of drafting services, some programming, and development of routine designs.

The dashed box is also used in Figure 1-4 to indicate the optional nature of the utilities operation and production responsibilities of the campus.

Large Maintenance Organization The large maintenance activity illustrated in Figure 1-5 differs from the medium-sized organization largely in size of function as opposed to distinction of function. It reflects an Associate Director position to assist the Director in managing the diverse and critical functions necessary for the successful operation of a college or university campus.

The large organization has sufficient size and resources to identify the planning and work control function (Control Center) as a distinct umbrella group over all physical plant activities. The work control function thus provides the management and control details that ensure greater efficiency, effectiveness, and reliability of the operating functions.

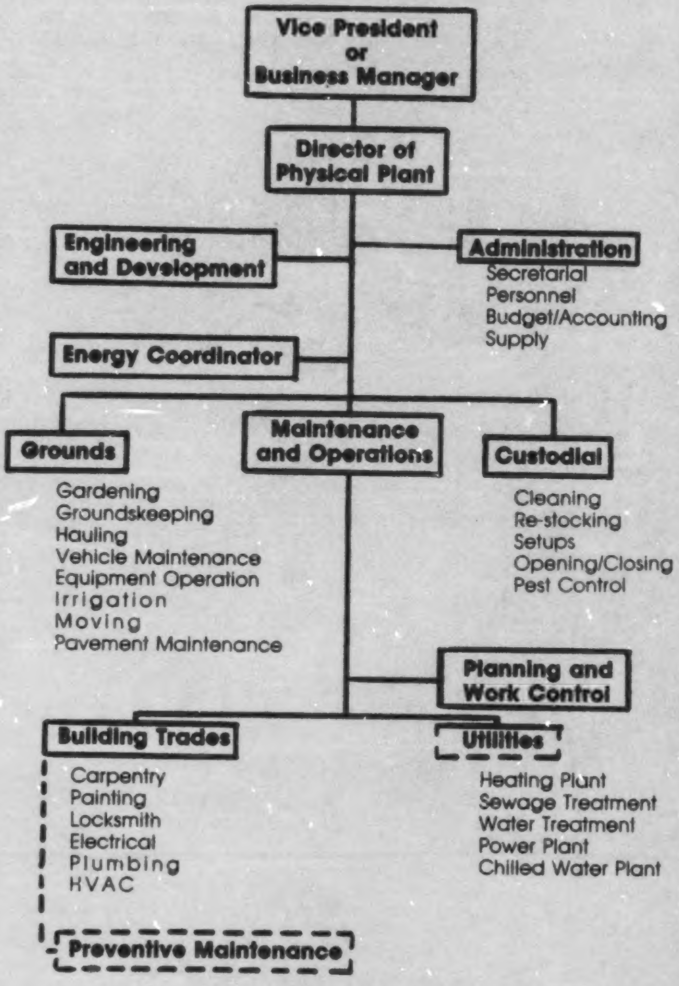
A greater proportion of large physical plant organizations are heavily involved in the production, treatment, and delivery of utility services. When that is the case, a distinct utilities function is practical.

Custodial and grounds maintenance are both labor intensive, share an indoor/outdoor interface for cleaning and policing, and tend to be tied together in collective bargaining units. This encourages the uniting of these functions under a single manager, especially if a separate utilities division is appropriate and the span of control problems begin to haunt top management.

The large organization requires and can afford a complete engineering function with the capability to plan, design, and contract in-house, much of the repair and minor capital improvement projects that all large facilities require. Some larger organizations include a special team of building trades people dedicated to full-time accomplishment of new work—minor construction, alterations, modifications, renovations, equipment installations. Generally the team can do a job cheaper than an outside contractor with less detailed plans and specifications. This effort may be construed as detracting from organization maintenance and repair capability and is generally frowned upon by the construction industry, trade unions, and state legislatures. Definite constraints on the scope of this kind of informal activity are frequently included in state laws, education codes, labor agreements, and administrative procedures.

Another distinction at some larger campuses is the consolidation of campus master planning and long range facility programming tasks with the

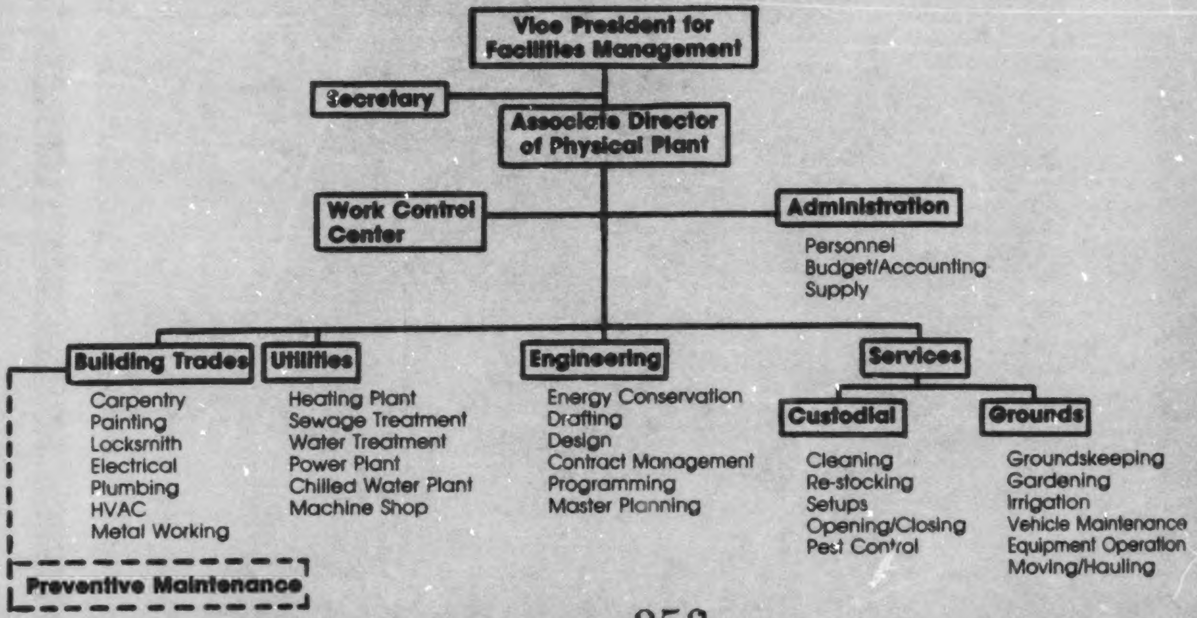
Figure 1-4
Typical Medium Sized Maintenance Organization*


Vice President
or
Business Manager
Director of
Physical Plant
Engineering
and Development
Administration
Secretarial
Personnel
Budget/Accounting
Supply
Energy Coordinator
Grounds
Gardening
Groundskeeping
Hauling
Vehicle Maintenance
Equipment Operation
Irrigation
Moving
Pavement Maintenance
Maintenance
and Operations
Custodial
Cleaning
Re-stocking
Setups
Opening/Closing
Pest Control
Planning and
Work Control
Building Trades
Carpentry
Painting
Locksmith
Electrical
Plumbing
HVAC
Utilities
Heating Plant
Sewage Treatment
Water Treatment
Power Plant
Chilled Water Plant
Preventive Maintenance

*500,000 GSF to 2 million GSF, 85 to 200 employees.

Figure 1-5

Typical Large Maintenance Organization*


Vice President for Facilities Management
Secretary
Associate Director of Physical Plant
Work Control Center
Administration
Personnel
Budget/Accounting
Supply
Building Trades
Carpentry
Painting
Locksmith
Electrical
Plumbing
HVAC
Metal Working
Utilities
Heating Plant
Sewage Treatment
Water Treatment
Power Plant
Chilled Water Plant
Machine Shop
Engineering
Energy Conservation
Drafting
Design
Contract Management
Programming
Master Planning
Services
Custodial
Cleaning
Re-stocking
Setups
Opening/Closing
Pest Control
Grounds
Groundskeeping
Gardening
Irrigation
Vehicle Maintenance
Equipment Operation
Moving/Hauling
Preventive Maintenance

*More than 2 million GSF and 200 employees.

physical plant engineering function in the maintenance organization. A discrete preventive maintenance speciality team can also be applied with good results in some institutions, usually under the direction of the building trades manager and the control center.

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CHAPTER 2

Maintenance Management Systems

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2.1 INTRODUCTION

This chapter describes maintenance management systems that can be used in the management of both small and large plant departments. The best system for a particular operation can probably be developed from those described. Plant administrators and their staffs can provide the best maintenance management system for their particular institution's facility.

Excessive reliance upon past practices, outdated procedures, and the resistance to change in the maintenance management field result in lower productivity and higher costs. New maintenance management systems and techniques make it possible to increase the productivity of people and reduce costs. Progressive maintenance management has advanced far beyond breakdown maintenance and fighting fires. It now includes management systems for requesting and authorizing work; planning, estimating, and scheduling work; performance measures and controls such as work sampling techniques; and cost accounting systems designed especially for controlling maintenance costs.

Objectives

The basic objectives of a well-designed and implemented maintenance management system are as follows:

1. Reduce overall maintenance costs by achieving the most from each maintenance dollar spent.
2. Minimize equipment and system breakdowns.
3. Optimize use of maintenance manpower, equipment, and materials.

4. Achieve better management control of planning, scheduling, quality of work, labor productivity, and costs.
5. Improve facilities and equipment maintenance in the broadest sense, including both the technical aspects and methodology.

2.2 WORK REQUEST SYSTEM

The work request system is the basis for establishing sound, accurate information upon which estimates, work orders, and follow-up can be based. Work requests can be generated from any element of the campus community, and thus they may be varied in style and detail, as well as their influence on the physical plant.

Any work request system should be as simple as possible while still providing the comprehensive information needed to get the job done by the proper service area. This would include the building name and number, room number, person making the request, and the type of service needed. Since these requests come from different parts of the institution, the request system must be flexible enough to meet all the needs of those who use it.

Requests for service from the plant department may come in the form of telephone calls, memorandums, preprinted forms, inspection forms, verbal requests, or by electronic mail. It is management's decision to determine how these different types of request formats will be handled by the work control program.

Requests from Within the Plant Department

Work requests that are generated from within the plant department come from several sources. These can include maintenance repair reports from housekeeping personnel, landscape personnel, building inspection reports, repair requests generated from the preventive maintenance system, or project requests. Generally, these requests come into the Work Control Center in written form. However, some minor maintenance tasks and requests for urgent (emergency) service are usually accepted by telephone.

Whatever the source of the request from within the department, it is essential that as much information as possible be obtained from the requestor. The information will help Work Control Center staff issue the appropriate work order to a service unit capable of accomplishing the designated task. At a minimum, the information supplied should include the following:

- Building name.
- Exact location where the work is to occur.
- Detailed description of work needed.
- Person making the request.
- Date.

This information might be all that is needed to generate a work order in a small institution. But in larger institutions, where detailed financial records are kept, a request with the following categories of information would be appropriate:

- Building/area name.
- Building/area number.
- Date of the request.
- Date by which the work must be completed.
- Urgency of the request. (Is essential service interrupted? Are there special deadlines to be met?)
- Exact location of job.
- Approval by appropriate administrator.
- Work classification. (Financial account for the type of job to be done.)
- Detailed description.

Also included might be—

- Specific machine number.
- Preventive maintenance or inspection report number generating the request.
- Special scheduling instructions.

Requests from Other Departments

The basic difference between work requests that evolve from within the plant department and those that come from other departments or administrative units is that often the area making this request will be billed for the services provided. Therefore, the information contained in the in-house request described above would also be needed on the request from an outside department or customer. The only additional piece of data needed would be the budget line or financial code to be used to fund the project.

The plant administrator should design a format most appropriate for the particular campus. Many departments use preprinted forms, while others prefer to have memorandums sent in for each request. Some organizations find that a combination of preprinted forms and letter requests works best for the operation.

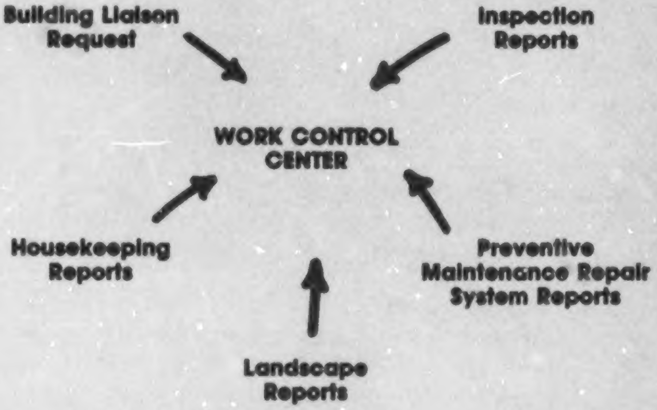
Another essential element of the request system from outside departments is the designation of authorized individuals to make requests for plant services. To avoid unauthorized or duplicate application for service or project work, a liaison system should be established. A designated individual makes requests for each building on the campus. The building liaison should be appointed through administrative channels so they will have the proper authority to complete their assignment. Building liaisons can help establish the priority of the request, schedule work within critical use areas, and assist in getting the proper detailed information to allow for timely service.

Flow Chart of Work Request System

Figure 2-1 illustrates the flow pattern for all requests including written, oral, or emergency.

Figure 2-1

Work Request Flow Chart


Building Liaison Request
Inspection Reports
WORK CONTROL CENTER
Housekeeping Reports
Preventive Maintenance Repair System Reports
Landscape Reports

2.3 WORK ORDER SYSTEM

The primary mission of a facilities organization is to provide services to the institution. The quality of this service and the response time to a request for service often are primary indicators of the image that the campus community has of the service organization.

In order to maintain a good service image the plant department must have a well-defined procedure for completing a work request by the appropriate service unit. The common document that accomplishes this task is the work order. The purpose of a work order system is to provide management control of a task from the time it is first reported until it is completed and billed through appropriate accounting procedures.

A basic requirement for a functioning work order system is a Work Control Center. This should be the only area within the department that accepts service requests and issues these tasks to the individual service units. Normally, the Work Control Center is also equipped with communications equipment such as radios, keys, and other support data to assist in the completion of work projects.

The size of a work control unit will vary with the size and organizational composition of the institution. At a small college the work control function may be handled by the director's secretary, whereas in a large institution the work control unit may include several clerks, a scheduler, a preventive maintenance coordinator, or a material expediter.

Whatever the size of the Work Control Center there are some basic elements that should be addressed in developing this function.

- Control of work flow. Administration of the work order system, estimating job costs, setting job priorities, scheduling, and work order coordination.
- Performance evaluation. Constant evaluation of shop performance against estimate.
- Long-range planning. Development of long-range scheduling to anticipate the needs of the building and service units.
- Documentation. Supplying management with the proper information on job performance, backlog, materials flow, and manpower utilization.

As a general rule, if plant administrators must document the costs in labor and material for specific tasks performed by the department, then they should operate a system that requires individual work orders to be issued for every task performed.

Work Generation

Following the receipt of a specific task that requires action by the maintenance staff, the Work Control Center must create an instrument that alerts the proper service unit and establishes the proper information channels to allow for an accounting of this work. This instrument is the work order.

The work order is without a doubt the most important document in the total work control system. It alerts a shop that there is a task to be completed, defines the location of the work, details the work to be done, allocates resources (estimates time and material to be used), authorizes the work, and certifies completion of the job. The format of a work order may vary, depending on the needs of the department. They may be computer generated, typewritten, or handwritten. Work orders should be consistent in the conveyance of information, and should usually contain the following information:

- Sequential work order number.
- Date of the request for service.
- Date of issue to the service area.
- Building/area where the work is to be done.
- Building number.
- Department making the request. (Physical plant is a department like any other.)
- Budget code to be charged for the work.
- Name of person making the request.
- Coordinator assigned to the project.
- Approval of appropriate administrator.
- Work classification number.
- Detailed description of the project.
- Scheduling details and assignment of priority (emergency, routine, renovation project).
- Assignment of appropriate shop or trade crew.
- Estimates of labor and materials to be expended on the job.
- Certification of completion by the appropriate supervisor.
- Date of completion.

Much of the information needed for the issuance of the work order can be obtained from the work request form. This relieves the Work Control Center of the task of gathering this necessary information.

Once the work order has been created, sufficient copies should be produced so that there is one for the Work Control Center, the cost accounting section, the coordinator, the scheduler, the shop supervisor, and the worker who will be assigned to complete the job. Also, some type of form should be generated to go back to the person making the request to inform him or her of the work order number and the schedule for the completion of that task.

Costs accrued against the work order number are captured by the accounting section. When the work order has been completed, it should be signed by the appropriate supervisor and submitted to accounting. This notifies management that the job can be billed as appropriate and is ready for inspection by the coordinator.

Work Authorization

Plant management should establish the appropriate level of approval needed to authorize a work order since the work order does generate an expenditure of funds. This would include those requests from other departments and from within the plant department. Again, the building liaison system can define those people authorized to have a work order issued for each department.

Within the plant, minor repairs or routine maintenance items could be authorized by a shop supervisor. Other types of routine maintenance should be approved by the work control supervisor or the scheduler. Any project-type work should be approved by the appropriate superintendent, assistant director, or director. All capital improvement projects undertaken by the facilities department must be approved by the director.

System Reports

The work order system should be structured to produce management reports that help the administrator monitor all aspects of the system. Basic reports that every system should include are—

- Jobs in Progress. Reports all work orders that are active in the system with their accumulated costs.
- Backlog Report. Indicates the jobs that have not been started that are in the system. A report of this nature should be kept by shop in chronological order.
- Completed Work Order Summary. All projects that have been completed over a designated period of time with performance by shop and efficiencies for management analysis.

Computerized systems enable plant administrators to create almost any type of report needed to better complete their assigned task, if the necessary data for the report are contained within the existing work order information.

Flow Chart of Work Order System

Figure 2-2 illustrates the flow pattern for all work orders.

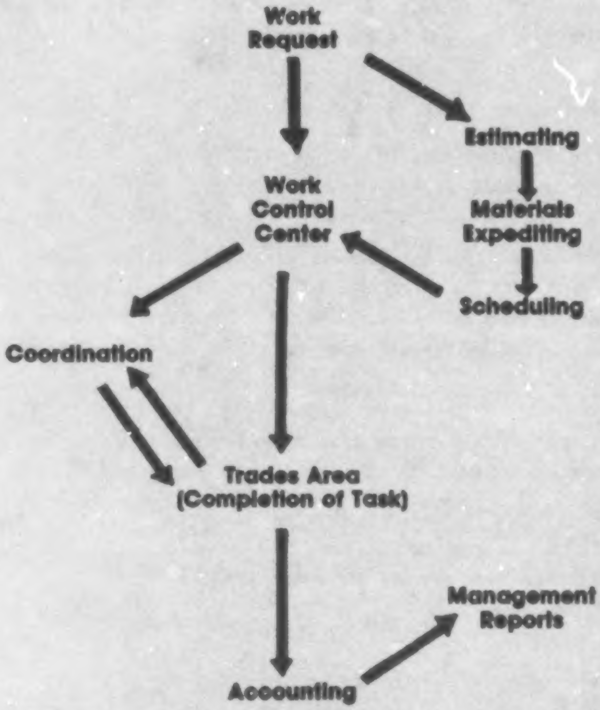
2.4 PLANNING SYSTEM

Planning is the process of deciding how organizational objectives will be met. It involves examining overall goals, establishing intermediate goals and objectives, defining alternate ways of attaining the objectives, and deciding which method to use. It is a process of thinking about a desired outcome and trying to anticipate what steps are necessary to produce it. In simplest terms, planning is decision making.

These familiar activities are all part of planning: setting goals, policies, and procedures; budgeting; estimating; designing facilities; and scheduling.

Figure 2-2

Work Order System Flow Chart


Work Request
Estimating
Work Control Center
Materials Expediting
Scheduling
Coordination
Trades Area (Completion of Task)
Management Reports
Accounting

Scope of Planning

Everyone in the organization must plan—from the custodian deciding what cleaner to use for a certain stain, to the director trying to decide how to reduce campus-wide energy use. One of the main differences among planners is the time frame with which they are dealing. Managers have to be concerned with both long- and short-range plans, while other employees can usually limit their concerns to immediate tasks.

Long-range plans normally project 3 to 10 years forward. A determining factor in facilities planning is the life of the buildings and equipment. Buildings are designed for a life of about 50 years, roofs 15 to 30 years, and equipment 3 to 15 years.

Short-range plans normally cover from one to three years while operating plans are for weekly, monthly, or quarterly time periods.

Long-Range Planning

Long-range plans are closely tied to the needs and goals of the academic and student communities, so close coordination is needed between plant managers and these groups.

Normally, long-range plans include such items as—

- Painting of buildings.
- Roof replacement or repair.
- Replacement or rehabilitation of basic building systems such as hot water heaters, boilers, air conditioning systems, and power distribution equipment.
- Major renovations.
- Replacement of motor vehicles.
- Replacement of physical plant shop equipment.
- Replacement of retiring employees.
- Replacement or major changes in landscape plant materials.
- Conversion from one energy source to another.

Ideally, long-range plans should evolve into short-range plans that translate into operating plans. When a plan is set and then constantly evaluated and changed over a long period of time, it has a much greater chance of success than does a plan that is hastily fashioned. Of course, not all plans can follow this evolution, but major ones with high financial consequences should proceed this way most of the time.

Short-Range Planning

Short-range plans should contain much less uncertainty than long-range plans. Factors such as student enrollment, equipment needing replacement, economic conditions, and funding are usually more predictable in the period of one to three years.

Typically, the first year is planned in considerable detail while the last two years are more general. Often, the first year is planned and stated in terms of budget categories and accounts.

One- to three-year plans are generally stated in dollar terms. Key goals or activities are enumerated with the dollars needed to attain or support them. Nondollar measures such as labor hours, planned work orders, manpower additions or deletions, target dates, and schedules are usually covered in operating plans for the current year.

Individual Job Planning

Physical plant activities can be broadly grouped into two types. (1) Activities that are predictable, continuous, and on-going on a daily basis. Examples are routine housekeeping and grounds maintenance; preventive maintenance; operation of systems such as heating plants, reclamation plants, and motor pools; and administrative and supervisory functions. Because of their repetitive nature, these activities are difficult to separate into projects or jobs that have a definite beginning, end, and purpose. (2) Activities defined on a job-by-job basis. In fact, most workhours in physical plants are spent on specific jobs or projects that can be described and planned fairly accurately. Methods for doing this are the subject of this section.

Elements One of the most important things to recognize about job planning is that even though all people are created equal, all jobs are not. Jobs differ in many ways—by priority, labor hours required, material content, degree of planning possible, whether the purpose is preventive or corrective, urgency, and time available for accomplishment. The differences are so significant, in fact, that managers establish different systems for handling the different types of jobs encountered.

Typically, two systems are used for job planning. The criterion used for deciding under which system a job will be handled is usually its labor content. A cutoff point is selected and jobs on one side are handled one way, and on the other side another way. The cutoff point varies with the organization but is usually in the 8 to 32 workhour range.

The reason a cutoff point is chosen in this range relates to the distribution of jobs, by size, usually found in plant departments. Analysis of the labor content of all jobs completed last year in an organization would show roughly the following characteristics: 80 percent of the jobs consume the time of only 20 percent of the work force, and conversely, 20 percent of the jobs consume 80 percent of the work force's time. The 80/20 relationship may vary 5 or 10 percentage points either way in a department, but the basic ratio remains.[1] The cutoff point for any organization is that labor content below which about 80 percent of the jobs fall.

Many managers, either intuitively or through actual studies, recognize that jobs exhibit these characteristics and design job planning systems accordingly. Their systems reflect detailed attention to the 20 percent of the jobs accounting for 80 percent of the work force, while the large number of small jobs receive much less detailed attention.

Small Job Planning Small jobs—those of less than 8 to 32 workhours, depending upon the cutoff point chosen—are the most difficult to plan. Most emergency, routine service, and minor repair tasks fall into this category. By their nature, and sometimes by their urgency, it is not practical to attempt to plan this kind of repair or service. More often than not, the exact nature of the job and the work required are not known until a mechanic arrives at the job site and makes a diagnosis. Usually the mechanic handles the job from beginning to end with little or no assistance.

Management planning for these jobs looks at them in aggregate rather than on a job-by-job basis. Systems such as the following are established to provide for effective performance:

- Separate crews, even separate shops, are established to respond to all small job requests.
- Attempts are made to stock material frequently used. Material planning and ordering is based on historical analysis of usage and on automatic reordering procedures.
- Versatile tools that are applicable to most minor jobs are stocked and supplied.
- Record keeping on work performed is often general in nature.
- Rapid means of dispatching workers are established with extensive use of radio and paging equipment.
- Often jobs are not estimated at all, or simple ballpark estimates are made.
- Except for emergencies, work is done on a first-in/first-out basis.
- Feedback and status reporting is usually on an exception basis—only when unusual problems arise.
- Scheduling is done by the shop foreman rather than a central staff scheduler.
- The mechanic is often the only plant employee who communicates with the user or customer.
- Minimal status checkpoints are established. All that may be known by anyone other than the mechanic is simply whether the job has been assigned or completed.

Compared to the systems established for larger jobs, the above methods result in relatively loose control of small jobs. However, the cost versus the benefit of tighter planning and control in this area is usually judged to be a poor exchange. In trying to get the most from limited resources, most managers choose to concentrate on large job planning.

The remainder of this section deals with planning large jobs—those above the 32 workhour cutoff point.

Estimating Effective management of the physical plant operation depends heavily on estimates. They are one of the basic foundations for planning and controlling construction and maintenance work. The importance of estimating can be better understood by considering how estimates are used:

- To determine whether a job is large enough for formal planning and scheduling activities.
- To determine the size of the work backlog.
- To schedule work on a daily, weekly, or longer term basis.

- To measure performance on an individual or shop basis.
- To quote costs to customers or other requestors of service.
- To compare in-house costs with contractor costs.
- To plan manpower increases or decreases.
- To establish budgets.

Estimates are used for many purposes, some requiring more accuracy than others. For this reason many estimating methods are in current use, and most plants use some combination of them depending upon the purpose for which the estimate is being prepared.

The common estimating methods involve use of historical records, estimator's experience, commercial data, contract data, and predetermined time standards. Some of these sources contain data on both material and labor, but most focus primarily on labor since material is easier to define, relatively speaking. Each estimating technique has its advantages and disadvantages.

While historical records can be useful for budget estimates or cost quoting, they are not usually adequate for scheduling or performance measurement. Too many variables are unknown. What kind of worker was assigned to that last job? Was he or she fast, slow, skilled, or unskilled? Were the working conditions normal? There is no way of knowing the answers to these questions. The best estimate that can be obtained using historical records is one that averages several similar jobs, if such information is available.

An estimator's experience can be an accurate estimating method that serves most purposes. Its major failing, however, is that estimators usually know only one or two trades well. In complex multitrade jobs, only certain phases will be accurately estimated.

Commercial data are generally developed on new construction work. They are frequently based upon repetitive tasks such as installing a number of new doors in a new building. New construction tasks differ from maintenance or renovation tasks. For example, the time to install a new door in a new building will usually be less than installing a new door in an old building. Thus commercial data are useful for new work, but not particularly applicable for intermittent maintenance work.

Contract data refer to developing estimates for in-house work by analyzing completed contracts for similar work. This has the same advantages and disadvantages as using historical records with the added problem of translating contractor prices into workhours.

Using predetermined time standards is potentially the most useful and accurate method of estimating. It has the advantages of consistency, accuracy, and universality. It is based on engineering studies that seek to determine an absolute, not relative, level of performance. Its main disadvantage is that more time is required to develop an estimate because the data are usually somewhat detailed and complex.

The most comprehensive body of data developed for maintenance work is that published by the Navy and called Engineered Performance Standards (EPS). Other predetermined time standards exist, but none covers as many trades or variety of maintenance tasks as EPS.[3]

Notice that the use of time study to develop one's own standards has not been mentioned as a viable estimating technique. Time study is too expensive for most organizations' budgets. Standards established by time study would require about 1 time-study employee for every 10 maintenance employees whose work was to be estimated. With EPS the ratio is closer to 1 estimator for 25 to 30 mechanics, and with historical estimates and commercial data the ratio is much higher—about 1 estimator to 50 mechanics.

Most plant managers begin by using a combination of the estimator's experience and historical records. As their overall systems develop and the need for control increases, they begin using some form of engineered predetermined standards. Few organizations, if any, rely solely on one estimating method. The method chosen is usually the least expensive one that will serve the purpose.

Method of Accomplishment Large job planning requires defining, step-by-step, how a job will be accomplished. All events necessary are listed in their proper sequence, labor workhour estimates including crew sizes are applied to each event, and the material and equipment needed for each event are defined. Once all this information has been documented, basic job planning has been done.

If time is of the absolute essence, or the job is unusually large or complex, additional planning techniques may be used. Bar graphs (Gantt Charts), PERT, and CPM are techniques for detailed planning that assure the minimum loss of calendar time. While these techniques are useful for planning individual projects, they are of little help in effectively managing many projects simultaneously. Still, for certain projects these techniques are necessary and beneficial.

The level of detail needed in describing and documenting each step or event depends upon how the job plan will be used. In organizations with refined systems, the writeup for each step is so complete that few decisions are left to the mechanic. For each step the writeup includes the shop involved, the trade within that shop, and a detailed method for accomplishing the task. In addition, bills of material, equipment lists, and drawings are also provided.

Managers using detailed planning such as this want to leave nothing to chance and want to minimize the number of decisions made by the shops and the mechanics. If supporting systems of equal refinement are in place, a high level of effectiveness and productivity results.

Most plant managers must settle for more general job plans that give a brief description of the event, the workhours required including crew size, the shop responsible for the event, and possibly the trade within that shop. Major items of material are also frequently specified, but not usually the equipment or tools needed.

The advantages of defining and documenting how a job will be accomplished are—

- It is absolutely necessary if any kind of effective scheduling is expected.
- Shop personnel are freed to concentrate on their prime responsibilities. Mechanics lose less time at job sites. Foremen have more time available for direct supervision.
- Those concerned with supplying material and equipment are better able to coordinate their efforts with the shops.
- Potential problems are recognized and solved before the job starts, not after.
- It provides a means of stating quantitatively the amount of work completed and remaining. This is valuable for progress reporting purposes.

2.5 SCHEDULING SYSTEM

Scheduling is an extension of planning. It defines, preferably in writing, what the plans are in terms of labor and—in sophisticated systems—material and equipment. It seeks to level the workload and it provides the basis for measurement of performance and control. Scheduling defines how resources will be used over a period of time and provides the basis for evaluating actual use versus planned use. Also, when work is being done for a customer, it is the means of determining milestones and completion dates.

Scheduling can be divided into three types: master scheduling, weekly scheduling, and daily scheduling.

Master Scheduling

Master scheduling is the broadest, longest range type of scheduling. It looks forward to a horizon that is at least three months, but can be years, in the future. A typical master schedule has the following characteristics:

- It has a three- to six-month horizon. This will depend mostly upon material delivery and the department's ability to adjust manpower up or down. If material deliveries are long and manpower is difficult to adjust, the master scheduling horizon will be extended farther out.
- Only large jobs or projects are scheduled. Typically, large means anything with more than 24 to 32 workhours of labor. No attempt is made to schedule emergency or minor repair work.

- The period of time covered by the schedule is divided into biweekly or monthly increments, or a combination of these. For example, if a six-month horizon is used, it might be practical to divide the first two months into four periods of two weeks each, and the remaining four months into four monthly periods. It is usually not practical to use shorter periods of time for master scheduling because too many uncertainties exist and too many changes will be made.
- A separate master schedule should be maintained for each shop so that individual skill or trade bottlenecks can be seen.
- Jobs are slotted into the time periods based upon shop capacity, material delivery expectations, customer's needs, and seasonal requirements. Any one of these factors, or all of them together, can influence how the job is scheduled.
- Care is taken to avoid exceeding the capacity of each shop. To do this, the capacity of each shop must be calculated and updated regularly. For master scheduling purposes, simple calculations are best. For example, if the carpenter shop has 5 people, its capacity is 200 workhours per week (5 workers × 40 hours/week/person).
- All available capacity is not scheduled. Typically only 50 to 80 percent of available workhours are scheduled. The remaining 20 to 50 percent are reserved for absenteeism, nonproductive work, and emergency and routine repair jobs. Figure 2-3 is an example of a typical master schedule.
- Master schedules are usually reviewed and approved at a high level in the organization. The projects scheduled are sizable, deadlines are important, and funds expended will be significant. In addition, good institutional relations can be greatly influenced by the plant department's performance on these projects.
- In well-run master scheduling systems, the schedule becomes frozen one to two months out; changes are only allowed in the third month and beyond. This greatly stabilizes the planning and scheduling process and contributes to high productivity and schedule reliability.

Weekly Scheduling

The master schedule feeds the weekly schedule with jobs or projects that have been anticipated and planned well in advance. The weekly schedule also contains large unplanned jobs that arise unexpectedly or result from a shift in priorities. Examples would be emergency repairs, new projects with a high priority in which material delivery is not a problem, or routine work that goes on continuously but cannot be defined too far in advance.

Figure 2-3

Typical Master Schedule

Shop Carpenter **Date** 3-14-84

Time Period	**1st Half April**	**2nd Half April**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**
Capacity (workhours/work day)	24	24	24	24	32	32	32	32
No. of work days in period	10	9	20	21	21	22	20	22
Planned workhours available	240	216	480	504	672	704	640	704
Total load (workhours)	200	220	470	450	370	340	340	240
Net workhours available	40	-4	10	54	302	364	300	464

Jobs or Projects		**Scheduled Workhours**							
# 6387	ABC Hall	180	10						
# 8522	XYZ Dorm		150						
# 3701	Bldg. #8			160	160				
# 2232	Bldg. #10 - Room 201	20	20						
# 6757	Bldg. #11 - Room 20		40						
# 8700	DEF hall			100	50	50			
New addition - XYZ Hall					80		120		
Dean Dokes office				180					
Alumni Bldg. roof							180	180	
Admin. Bldg. renovation				30	160	160			
Stairway West Parking						160			
Bldg # 8 - Rms. 101, 102, 103							40	160	
Bldg # 12									240

Weekly schedules have the following characteristics:

- While master schedules cover only 50 percent to 80 percent of shop capacity, weekly schedules attempt to cover 80 percent to 90 percent of shop capacity.
- Jobs under 24 to 32 workhours duration are not included on the weekly schedule.
- Weekly schedules, which are issued for each shop, reflect known absenteeism (vacations or sick leave) in the shop capacity figure for a given week.
- The weekly schedule does not define the individual mechanics' daily work. This is done under daily scheduling. The weekly schedule shows simply the number of workhours that should be spent by each shop on each job for every day of the work week. Figure 2-4 is an example of a typical weekly schedule form.
- Jobs are not scheduled until major items of material have been checked for availability.
- Weekly meetings are held between the scheduler and shop supervisors to communicate actual versus scheduled performance.
- The scheduler is in constant contact with the shops to stay informed of manpower availability and changes. This is necessary to assure that the shops are not under- or over-loaded due to unknown manpower situations.

Daily Scheduling

Daily scheduling is the process of converting the weekly schedule into individual mechanics' daily assignments. This is best done by the shop foreman. Foremen typically do this by simply posting the daily job assignments next to individuals' names on a blackboard or other type of visual display. This board is placed in a conspicuous location in the shop and is updated regularly (at least daily).

Not surprisingly, organizations that have no other scheduling procedures do have rudimentary daily scheduling at the shop level by foremen. When master scheduling and weekly scheduling are also installed, supervision finds that daily scheduling becomes more effective because it becomes part of an overall coordinated plan. Daily scheduling by a foreman covers not only the large jobs on the weekly schedule but also the small emergency and routine repairs (under 24 to 32 workhours duration). Except in the most sophisticated systems, these small jobs are best handled at the shop level on a first-in/first-out basis—with due regard for their priority, of course.

Figure 2-4

Typical Weekly Schedule

Date ____________________

Shop ____________________

Gross Workhours Available ____________________

Minus Leave Time ____________________

Net Workhours Available ____________________

Job Number	Location	Daily Workhours Scheduled					Total Hours Sch'd	Percent Completed	Comments
		Mon	Tue	Wed	Thu	Fri			

Necessary Prerequisites

Certain basic systems must be in place—or must be installed—before anything more refined than daily scheduling is attempted. The following elements should be present before installing weekly scheduling or master scheduling:

- A step-by-step description of the work should show the shop required and the labor hours needed for each step. It is important that the steps reflect the actual sequence of the job.
- The major items of material should be listed if a warehouse or shop inventory exists to supply the minor items. If no stock is on hand, all items of material must be listed.
- In multitrade shops it may be necessary to specify the trade as well as the shop.
- The delivery status of materials not on hand must be tracked. If stockrooms exist for common items, only material unique to individual jobs need be checked. If no stockrooms exist, all materials for each job scheduled must be tracked.
- In all but the smallest organizations a work order system should be in place.

2.6 COST ACCOUNTING FOR MAINTENANCE MANAGEMENT

Every plant director needs some means of accounting for maintenance expenditures. One way is to use an operating budget that can report monthly and year-to-date actual expenditures and encumbrances against the overall annual budget. This is an essential tool for the director and represents the real world of actual expenditures against budgeted funds. However, most operating budgets tend to summarize cost items and have no allowances for the kind of detail a director needs to manage efficiently.

To meet this need for detailed cost information concerning such expenses as annual repair charges in a given residence hall or the specific charges on a given job order, the director needs some type of cost accounting system. The type of system depends on the size and type of institution, the budget available to support a cost accounting staff, and the manager's personal emphasis on the need for this type of detailed reporting.

Whatever type of system, it is important to remember that cost accounting systems are, for the most part, based on standard and average cost information. This information approximates actual expenditures but does not always equal the actual cost as reported against the operating budget.

Although an average or standard cost system may not tie exactly to the actual costs incurred on a particular job, it does give the manager an excellent approximation of that cost. And it is often a fairer cost, especially if a self-supporting facility is paying for the service. When a shop charge rate is based on an overall average or composite of the individual salaries within the shop, problem situations are avoided whereby one department might receive a larger bill because the highest paid mechanic happened to handle that particular service call.

Establishing a Standard Cost System

The first matter to address in establishing a cost accounting system is to determine what type of labor rates will be utilized. One system might use broad overall rates based on certain segments of the organization's salary grades, with rates designated for laborers, trades helpers, and mechanics. Another system might base its rates on job classifications, with different rates for a Carpenter I or a Carpenter II.

A third approach, and the one that will be addressed in detail here, involves establishing a standard labor charge rate for all employees within a particular shop or work unit. This composite rate is used to account for all labor charged out by the shop during the fiscal year.

To establish a shop rate, pertinent data on shop personnel must first be summarized. See Figure 2-5. In this simplified example all employees in the shop and their current salaries have been included. Next, the cost of employee benefits paid by the employer are added, as well as the individual shop's share of direct supervision and support costs allocated on the basis of employee count.

Figure 2-5 reflects a total annual cost of $132,200 for salary related items. This figure is divided by 8, the number of positions in the shop, to get an average cost of $16,525 per position. This average cost is then divided by 2,080 hours (40 hours/week × 52 weeks/year) to get an hourly shop rate of $7.94.

This shop rate of $7.94 per hour is called the cost accounting rate and will be used to calculate labor charges for maintenance and repairs funded in the physical plant budget and to assign dollar values to annual leave, sick leave, holidays, etc.

Leave Factor When billing a self-supporting facility for work not provided for in the plant budget, the cost accounting rate—in this example $7.94—will be indexed by a leave factor of 1.1429 to absorb the cost of holidays, annual leave, and sick leave. This indexing is justified for the following reason: If the self-supporting facility were to employ its own carpenter, it too would only have the carpenter's services available for approximately 1,820 hours per year, rather than the 2,080 hours for which the carpenter is paid.

The annual salaries for direct labor employees are based on 52 weeks in a year at 40 hours each week for a total of 2,080 hours a year. However, an individual worker will not be available to actually work 2,080 hours a year due to holidays, annual leave, and sick leave.

Studies at one university show that the average number of weeks taken per employee per year is as follows:

Figure 2-5

Salary and Staff Benefit Summary

Position Title	Position No.	Salary Grade	Salary Step	Actual Salary
General Utility Worker	73489	53	1	$ 8,500
Trades Helper	73458	57	3	11,000
Carpenter I	73484	57	2	10,500
Carpenter I	73492	57	4	11,500
Carpenter II	73464	61	2	12,500
Carpenter II	73520	61	7	15,500
Cabinetmaker	73564	61	5A	14,000
Carpenter Supervisor II	73551	65	4	16,500
Position Count 8		Subtotal		$100,000
FICA		6.70%		6,700
Retirement		9.90%		9,900
Health Benefits		$425 @ 8		3,400
		Total		$120,000
Direct Supervision and Support (See Figure 2-6)				$ 12,200
		Total		$132,200
Average cost per position		$16,525		
Cost per hour		$7.94		

	Weeks Taken
Holidays	2.0
Annual Leave	2.6
Sick Leave	1.9
Total	6.5

These 6.5 weeks represent a leave index factor of 14.29 percent.

Total Annual Hours 52 × 40 = 2,080
Leave and Holidays 6.5 × 40 = (260)
Available Hours 1,820

260 Leave Hours ÷ 1,820 Available Hours = 14.29 percent
2,080 Total Hours ÷ 1,820 Available Hours = 1.1429

Figure 2-6

Schedule of Direct Supervision and Support

Direct Supervision and Support	**Shop**	**Carpenter**	**HVAC**	**Plumbing**	**Total**
	Direct Employees	8	10	14	32
	Percentage	25%	31%	44%	100%
Position	**Gross Salary**				
Trade Services Superintendent	$22,000	$ 5,500	$ 6,820	$ 9,680	
Secretary IV	9,800	2,450	3,038	4,312	
Area Coordinator	17,000	4,250	5,270	7,480	
	Totals	$12,200	$15,128	$21,472	

Therefore, to absorb the cost of this nonproductive time the carpenter shop's cost accounting rate of $7.94 per hour is indexed up by the factor of 1.1429 to a Billing Rate of $9.08.

Figure 2-5 showed only a small portion of overhead costs being absorbed in the labor rate. Obviously in some organizations there will be a considerable amount of administrative overhead. Whether all or part of this overhead is absorbed depends on the specific institution's overall budget structure and the organization's need to recover those costs from self-supporting facilities on campus.

Material Costs In addition to labor, the other major component of a cost accounting system will be material or supply costs. Here, as with labor rates, there are limitless variations that can be used to charge out materials. Some organizations charge materials at current cost, others at average cost. Some index these costs to cover overhead expenses, and still others only index materials that are charged to self-supporting facilities. Again, the type of system used depends on the individual institution's budget and billing philosophy.

Computerized Cost Accounting

Once the method of deriving labor and material charge rates is established, management needs some type of system (preferably a computerized one) to track, record, and invoice these charges. Again, there are an infinite number of systems available; however, for this discussion, we will examine only one.

This job order system starts with the premise that all labor and material costs will be charged to individual job order numbers with the exception of leave, holidays, and training sessions. Job orders contain the following information (data elements) directly related to the cost accounting system:

1. Department responsible for the charges. Physical plant or self-supporting facility.
2. Building/Area/Vehicle Number. "Ledger" number used to record charges made throughout the month and fiscal year from the various individual job orders.
3. Work Classification Code. A numeric code with a descriptive alpha statement used to distribute charges within a particular building, area, or vehicle, for example, 2220 Floor Tile Repairs. This information is used to give some detail to the charges made in a building during a month or fiscal year. Following is a partial listing of work classification codes.

21XX	Building Shell
	2110 Door Closers
	2120 Door Numbers
22XX	Floors
	2210 Floor Refinishing
	2220 Floor Tile Repairs
	2230 Ceramic Tile Floors
23XX	Foundations and Footings
	2310 Waterproofing
24XX	Roofs
	2410 Waterproofing
25XX	Walls
	2510 Masonry
	2520 Painting
	2530 Plaster
	2540 Millwork
	2550 Sheetrock Installation
	2560 Sheetrock Patching and Repairs
	2570 Window Screens
26XX	Windows
	2610 Blind Repairs
	2620 Glazing
	2630 Window Repairs
	2640 Window Shades
	2650 Security Screens
	2660 Storm Windows
	2670 Window Screens
27XX	Hardware
	2710 Key Cutting
	2720 Lock Combination
	2730 Lock Installation
	2740 Lock Repairs

4. Coordinator. Responsible for seeing that all shops phase their work properly and that the job is complete before a final billing is made.
5. Work Category. Used to indicate type of billing to be made—a regular invoice or transfer voucher
6. Description/Instructions. Detailed information on the particular task to be performed.
7. Estimate. Projected costs for the work broken down by labor hours and dollars, material dollars, and total labor and material dollars.
8. Shops Involved. Listing of the shops authorized to perform work and charge against a particular job. Gives an estimated completion date by shop and the individual estimate of labor and material costs by shop.

Daily Time Sheets Shop employees complete a daily time sheet, listing the individual job orders they worked on and the time spent on each job. These time sheets are preprinted by the computer system with the employee's name, social security number, and assigned shop. See Figure 2-7.

The time sheet information is entered on a CRT terminal by a cost accounting clerk. The system edits this data on-line and, if correct, stores it on a disc for overnight updating.

Material Tickets Daily issues from the physical plant warehouse are, in most cases, charged directly to individual job order numbers. Those items that are not charged directly are transferred to the shop's stock and charged out as they are used on individual jobs. These material tickets are accumulated in the cost accounting office and entered via CRT terminals in a manner similar to time sheet entry.

On-Line Information Once the time sheet and material charges have been updated to the system, direct on-line inquiry can be made into the system through the same CRT terminals used to enter the data.

This on-line inquiry gives the supervisor or manager virtually instant access to the individual status on any job order. Elements on the inquiry screen include:

Job order number
Priority
Work category
Purchase order/reference number
Work classification code and short alpha description
Coordinator's name
Building/area/vehicle number and name
Who requested the work
Who approved the job order issue
Description of work requested

- Responsible department
- Dates:
    - Requested by customer
    - Passed to scheduler's file
    - Issued to first shop involved
    - Estimated completion
    - Last transaction
    - Completed
- Financial code information
- Summary of estimated and actual charges based on labor hours/dollars and material dollars
- Efficiency percentages
- Amount invoiced to date

Also available on a separate inquiry screen, accessed through the one described above, is detailed information for each shop involved in the job. This screen shows the following information for each shop involved in the job.

- Dates:
    - Estimated completion
    - Issue
    - First transaction
    - Last transaction
    - Completion
- Estimated charges
- Actual charges
- Efficiency percentages

With the above on-line information and hard copy reports of jobs in progress, the job order coordinators, shop foremen, and plant managers have ample access to the information they need to manage the organization efficiently.

This information, and a special billing report that highlights those jobs ready to be billed, is used by the cost accounting staff to invoice self-supporting facilities for work they request.

Monthly Reporting As a part of the computerized cost accounting system, several management information reports can be produced on a monthly or more frequent basis. These reports should show both current period (usually current month) and fiscal year-to-date information. Labor and material charges are reported by shop unit with grand totals for the entire operation.

Figure 2-8 shows an example of a cost accounting system report for Departmental Services. It displays the current month and year-to-date labor and materials expended on services to self-supporting facilities. Note that the labor figures by individual shops are reported in the cost accounting rate, and only the grand total is indexed up to the billing rate.

Figure 2-7

Physical Plant Daily Time Sheet

Name: ____________ Shop: ____________ SSN: ____________ Date: ____________

Overtime ☐ (Enter your work activity row by rown, from left to right as numbered.)

Job Order	**Hours**	**Job Order**	**Hours**	**Job Order**	**Hours**
1. ____________	___.___	2. ____________	___.___	3. ____________	___.___
4. ____________	___.___	5. ____________	___.___	6. ____________	___.___
7. ____________	___.___	8. ____________	___.___	9. ____________	___.___
10. ____________	___.___	11. ____________	___.___	12. ____________	___.___
13. ____________	___.___	14. ____________	___.___	15. ____________	___.___
16. ____________	___.___	17. ____________	___.___	18. ____________	___.___
19. ____________	___.___	20. ____________	___.___	21. ____________	___.___
22. ____________	___.___	23. ____________	___.___	24. ____________	___.___
25. ____________	___.___	26. ____________	___.___	27. ____________	___.___
28. ____________	___.___	29. ____________	___.___	30. ____________	___.___

TOTAL HOURS ___.___

Employee's Initials ________ **Foreman's Initials** ________

Figure 2-8

Departmental Services Report

DEPARTMENTAL SERVICES	**Current Month**				**Year To Date**			
Operations	**Labor Hours**	**Labor $**	**Material $**	**Total Labor & Material $**	**Labor Hours**	**Labor $**	**Material $**	**Total Labor & Material $**
I. Building Serv.								
Coliseum Crew	—	$ —	$ —	$ —	—	$ —	$ —	$ —
Floor Crew	11	71	—	71	47	321	1	322
Housekeeping	131	747	38	785	202	1153	38	1191
Pest Control	101	888	179	1067	215	1907	321	2228
Radiation Crew	16	88	—	88	38	213	—	213
Sub Total Build. Serv.	259	$ 1794	$ 217	$ 2011	502	$ 3594	$ 360	$ 3954
II. Landscape Serv.	1067	$ 6741	$ 360	$ 7101	1179	$ 11228	$ 374	$ 11602
III. Trade Services								
Carpenter	2126	$ 19213	$ 13659	$ 32872	3626	31809	$ 16039	$ 47848
Electric	1043	9314	9506	18820	1933	16998	11598	28596
General	1190	9282	2303	11585	1786	13933	2723	16656
Hardware	363	3570	4212	7782	600	5838	5166	11004
Paint	758	6517	915	7432	1161	9979	1722	11701
Plumbing	991	8532	2674	11206	1556	13263	4074	17337
Refrigeration	662	6436	2260	8696	1247	12374	4832	17206
Sub Total Trade Serv.	7133	$ 62864	$ 35529	$ 98393	11909	$ 104194	$ 46154	$ 150348
Sub Total Operations	8459	$ 71399	$ 36106	$ 107505	14190	$ 119016	$ 46888	$ 165904

Word Processor	—	$ —	$ —	$ —	—	$ —	$ —	$ —
Vet Services	—	$ —	$ —	$ —	—	$ —	$ —	$ —
General Services								
Automotive Garage	178	$ 2307	$ 3243	$ 5550	347	$ 4522	$ 4931	$ 9453
Heavy Equipment	389	3763	300	4063	707	6686	480	7166
Mail Crew	—	—	—	—	—	—	—	—
Motor Pool	—	—	—	—	—	—	—	—
Warehouse	—	—	—	--	2	14	—	14
Waste Disposal	8	78	—	78	16	156	—	156
Sub Total Gen. Serv.	575	$ 6148	$ 3543	$ 9691	1072	$ 11378	$ 5411	$ 16789
Engineering								
Design Services	42	$ 777	$ —	$ 777	53	$ 1000	$ —	$ 1000
Steam Plant	—	—	—	—	—	—	—	—
Sub Total Engineering	42	$ 777	$ —	$ 777	53	$ 1000	$ —	$ 1000
Grand Total DPS	9076	$ 78324	$ 39649	$ 117973	15315	$ 131394	$ 52299	$ 183693

Preventive Maintenance

Time and materials spent doing preventive maintenance are an important element of any cost accounting system and should be reported separately from regular maintenance work. In a computerized system job orders for preventive maintenance can be assigned a special code or work category and the computer programmed to report this as a separate item.

Cost Accounting/Equipment Number System

Cost accounting systems benefit from logical numbering schemes as much as do general purpose accounting systems. Use alpha codes rather than numeric codes wherever possible. Computers can easily handle both alpha and numeric codes, and it's much easier for managers to remember an alpha code such as CR for carpenter shop, than a numeric code such as 2310.

When it is more efficient to use numeric schemes be sure that they help the employees use the information the numbering system represents. For instance, if vehicle numbers are assigned to the campus motor pool, don't just start with number 1 and go from there. Plan the scheme in a logical and systematic manner as in Figure 2-9. This will help identify the vehicle type by its number.

Federal regulations require colleges and universities to depreciate their property, plant, and equipment as a part of figuring overhead rates for federal contracts and grants. To comply with these regulations, institutions have established comprehensive asset management systems. Usually these systems require that any piece of movable equipment with a value of $200 or more be tagged and inventoried at least once a year.

If possible, incorporate these fixed asset numbers into the cost accounting system. However, with the volume of items to be inventoried from the entire campus community, these numbers may not be suitable if the department is responsible for plant property and equipment only.

Figure 2-9

Motor Pool Numbering System

Number Series	Vehicle Type
1000 - 1999	Subcompact sedans
2000 - 2999	Compact/mid-size sedans
3000 - 3999	Full-size sedans
4000 - 4999	Compact/mid-size station wagons
5000 - 5999	Full-size station wagons
6000 - 6999	Cargo vans
7000 - 7999	Passenger vans
8000 - 8999	Buses
9000 - 9999	Trucks

2.7 PERFORMANCE MEASURES

Performance measurement is an ingredient of control. It tells management how its operation compares with accepted standards. These standards may be generated internally or they may come from outside sources. Both are needed.

Internal standards usually relate to the budget in some way, or to an individual department's unique goals and objectives. Examples of internal standards might be—

- A 20-day backlog of work should be maintained at all times.
- Actual job costs should be within 10 percent of the estimates.
- Actual labor performance should be from 95 percent to 105 percent of standard labor.
- Energy use should not exceed 100,000 BTUs per square foot per year.

These kinds of standards will vary from one organization to another. The most effective standards are those tailormade to the institution's needs.

Sooner or later, most managers begin to wonder how their operations compare to other physical plants at other schools, or to the typical school. They seek performance measures common to all physical plants. They even wonder whether absolute measures of performance are available rather than measures that are relative to someone else. Managers know, for example, that the time required to run 100 feet of conduit can be measured on an absolute basis. It should take the same amount of time anywhere, assuming workers of equal ability do the job and similar conditions exist. Before long, managers will also ask whether an absolute amount exists for custodial costs per square foot.

Few absolute measures exist against which actual performance can be compared. Most measurements are relative to past performance, are in index or ratio form, and are most meaningfully analyzed using trend lines and charts.

The remainder of this section will discuss measures that are (1) in wide use and published, and (2) more specific and best left to individual schools to develop for their own internal use.

Published Performance Indicators

The most comprehensive and useful publication for plant administration is published by the Association of Physical Plant Administrators of Universities and Colleges. Every two years APPA surveys its members via questionnaire and publishes the results in its *Comparative Costs and Staffing Report.*[3] This report allows comparisons of costs per gross square foot for various physical plant functions. It also compares the number of full-time employees required to maintain and operate facilities, and the average wage and salaries paid to these employees.

The 1982-83 edition represents a compilation of 760 responses from 3,100 questionnaires sent to institutions comprising the membership of APPA and the National Association of College and University Business Officers (NACUBO).

Following is some of the information reported by each participating institution:

- Full-time equivalent (FTE) student enrollment.
- Total gross square footage of all buildings.
- Gross square footage maintained in physical plant budget.
- Ground acreage.
- Administration cost per gross square foot (GSF).
- FTE administrators.
- Engineering cost per GSF.
- FTE engineering personnel.
- Maintenance cost per GSF.
- FTE maintenance employees.
- Custodial cost per GSF.
- FTE custodial personnel.
- Landscape and grounds cost per GSF.
- FTE landscape and ground personnel.

The report presents the above information and explains how to make meaningful comparisons. Managers can compare performance to institutions of similar size, type, and educational purpose.

Other information—although not nearly as comprehensive as APPA's report—is published periodically in various trade journals. *American School and University* annually publishes a maintenance and operations cost survey with costs analyzed as follows:

- Custodial salary stated in dollars per pupil and per square foot.
- Maintenance salary stated in dollars per pupil and per square foot.
- Heat, other utilities, and other costs stated in dollars per pupil and per square foot.
- Average custodial and maintenance salaries.
- Square feet per custodian.
- Square feet per maintenance worker.[4]

The above categories are presented based on school size and geographic region. National averages as well as national cost trends covering the previous 11 years are presented.

Another source of comparative data is *Cleaning Management*. The December/January 1979 issue published results of a survey of 1,410 institutions.[5] This survey generated some useful information on the cost and size of building cleaning maintenance/housekeeping operations throughout the country. The survey covered *only* custodial costs. It was not meant to gather information on building or grounds maintenance.

At best, the published indicators are only a guide. Large differences are often noticeable between—to all appearances—similar organizations. These wide variations reflect not only the differences in the cost of maintenance but also the differences in methods of accounting for costs. For this reason, most managers develop their own internal measures and judge performance against internally set standards. Periodically, and with some reservation, managers look at their organizations compared to others.

Internal Performance Indicators

Managers have the most confidence in the measurements they establish for their own operations. They know exactly what is being measured, the source of the information, its reliability, and its intended use.

Even though meaningful comparisons of one organization to another are difficult, there are remarkable similarities in the things organizations measure. Each seems to need to measure the same basic performance factors. In one way or another, measurements usually relate to labor productivity, materials usage and cost, energy usage, quantity of work done, quality of work, timeliness of service, and job cost.

Performance measures are usually expressed in index (ratio) form. In establishing indexes managers must carefully consider two questions: What do I want to control? and, What index will indicate the performance? After selecting appropriate indexes, target values of desired performance must be selected. These will probably be based upon budgets, past history, or future goals and objectives.

Performance measures are specific to each institution, so it would not be possible to list those measures applicable to individual organizations. Typical indexes and indicators are listed in Figures 2-10 through 2-18.[6]

2.8 MANAGEMENT CONTROLS

Managerial control is the process of comparing actual results with planned or expected results and taking corrective action if the deviation is judged unacceptable. The corrective action frequently takes the form of additional planning, organizing, and directing. In many ways the need for control drives the other management processes.

Many people mistakenly think that reams of written procedures and reports represent good control. This kind of paperwork can be found in both excellently and poorly managed facilities. Effective control starts with managerial observation and evaluation, it is enhanced by proper organization of activities, and it is aided through feedback and reporting.

Figure 2-10

Work Order Control Indicators

No.	Index	Units	Comments
1	$\frac{\text{Cumulative work orders received}}{\text{Number of days in the period}}$	Number per day	One of the best indicators for anticipating a short-term change in the work load
2	$\frac{\text{Cumulative work order completed}}{\text{Cumulative work orders received}}$	Percent	Good indication of short-term balance between resources and demand; gaining on backlog or falling behind.
3	$\frac{\text{Cumulative work orders completed}}{\text{Number of days in the period}}$	Number per day	Indicates rate of work being accomplished
4	Number of work orders in backlog	Number	A snapshot of backlog size on a given date. Provides a cross check on No. 2, but may be affected by laxity in closing work orders completed or awaiting late charges due to delayed invoices. No. 5 is better indication of backlog size.
5	$\frac{\text{Backlog work content, workhours}}{\text{40} \times \text{number of workers available}}$	Weeks	
6	$\frac{\text{Cumulative ``emergency'' work orders received}}{\text{Cumulative work orders received}}$	Percent	The analysis of work orders received by priority level give a good indication of the time being allowed for scheduling of resources, whether the priority system is being abused, and how well the demand is balanced. No. 6 should be held to 10 to 20 percent and No. 7 should not exceed 15 percent.
7	$\frac{\text{Cumulative ``urgent'' work orders received}}{\text{Cumulative work orders received}}$	Percent	
8	$\frac{\text{Cumulative ``routine'' work orders received}}{\text{Cumulative work orders received}}$	Percent	
9	$\frac{\text{Cumulative ``preventive'' work orders received}}{\text{Cumulative work orders received}}$	Percent	
10	$\frac{\text{Cumulative ``turnaround'' work orders received}}{\text{Cumulative work orders received}}$	Percent	
11	$\frac{\text{Cumulative ``preventive'' work orders received}}{\text{Cumulative ``repair'' work orders received}}$	Percent	Used to monitor effectiveness of preventive maintenance effort.
12	$\frac{\text{Cumulative workhours worked overtime}}{\text{Cumulative workhours worked straight time}}$	Percent	Like No. 2, a good indication of balance between resources and demand.

Figure 2-11

Backlog Control Indicators

No.	Index	Units	Comments
1	$\dfrac{\text{Backlog work content, workhours}}{40 \times \text{number of workers available}}$	Weeks	Same as no. 5 in work order control.
2	$\sqrt[n]{\text{Product of ages of all work orders}}$ where n = number of work orders in backlog	Days	The geometric mean is appropriate for expressing the mean of a highly skewed distribution with a zero origin.
3	Same as no. 2, but for priority level 1, etc.	Days	Comparison with no. 2 value gives good picture of reasons for delays in work completion.
4	Same as no. 2, but for skill "A" only, etc.	Days	
5	Same as no. 2, but for area "A" only, etc	Days	
6	$\dfrac{\text{Backlog work content, workhours, skill "A" etc.}}{40 \times \text{number of skill "A" etc. workers available}}$	Weeks	Study of trends will detect if backlog is real or being maintained by craftsmen for a feeling of job security. Monitor for staffing levels.
7	$\dfrac{\text{Active backlog work content, workhours, skill "A" etc}}{8 \times \text{number of skill "A" etc., workers available}}$	Days	Active backlog of work orders that could be done today if manpower available. 10 to 15 days is healthy, but varies by work load and craft.

Figure 2-12

Planning and Scheduling Control Indicators

No.	Index	Units	Comments
1	$\frac{\text{Actual time charged to scheduled work workhours}}{\text{Scheduled time for scheduled work, workhours}}$	Percent	Good indication of quality of time estimates. These indexes should run close to 100 percent. Low results would indicate interruptions to the daily schedules or poor plans. High results, 120 percent or greater, are usually due to poor manpower estimates.
2	$\frac{\text{Scheduled time for scheduled work, workhours}}{\text{Estimated time for scheduled work, workhours}}$	Percent	
3	$\frac{\text{Actual time charged to scheduled work, workhours}}{\text{Estimated time for scheduled work, workhours}}$	Percent	
4	$\frac{\text{Unscheduled work, workhours}}{\text{Scheduled work, workhours}}$	Percent	Index indicates the quality of scheduling and how well the schedules are being followed.
5	$\frac{\text{Work scheduled, workhours}}{\text{Time and workers available for scheduling, workhours}}$	Percent	Indicates flexibility of craft lines and work procedures. Also indicative of manpower utilization and backlog. Should run about 95 percent.
6	$\frac{\text{Time and workers available for scheduling, workhours}}{\text{Total work performed, workhours}}$	Percent	Numerator is a forecast. Denominator is what actually happened. Indicative of how well the number of workers present each day is being forecast.
7	$\frac{\text{Emergency priority jobs worked on regular time, workhours}}{\text{Total work performed, workhours}}$	Percent	Used in conjunction with nos. 8 and 9, gives an indication of real emergency work needs vs. people abusing priority system to have non-emergency work done immediately.
8	$\frac{\text{Overtime for work during normal day shift, workhours}}{\text{Total work performed, workhours}}$	Percent	Indicates shift personnel working on days to handle work load in excess of day-worker capacity.
9	$\frac{\text{Total overtime worked, workhours}}{\text{Total work performed, workhours}}$	Percent	Optimum level usually ranges from 3 to 8 percent. "Lean and hungry" staffing levels may lead to 12 to 15 percent normal and economic. Over 15 percent leads to worker fatigue and should be avoided. Little or no overtime may indicate (a) poor planning and scheduling, (b) equipment abuse/neglect, (c) overstaffing, (d) management edict, or (e) lax supervision.

Figure 2-43

Contractor Control Indicators

No.	Index	Units	Comments
1	$\frac{\text{Number of contractor workers}}{\text{Total number of plant engineering workers}}$	Percent	Generally ranges about 30 percent level for best results. Too few contractors may indicate overstaffing. Too many contract people may indicate too few employees to handle critical work, leads to a reduction of bargaining power and makes institution vulnerable to contractor work stoppages.
2	$\frac{\text{Total contractor workhours worked}}{\text{Total plant engineering workhours worked}}$	Percent	Eliminates effects of absenteeism from no. 1.
3	$\frac{\text{Contract workhours worked by craft}}{\text{Total workhours worked by craft}}$	Percent	Indicates level of contract work by craft; ideal level varies by craft—lowest levels in shops, electrical and instrument, highest levels in field crafts.
4	$\frac{\text{Maximum workhours demand by craft}}{\text{Base workload workhours by craft}}$	Percent	Indicates the volatility of demand for a craft and should be compared to actual usage reflected by no. 3.
5	$\frac{\text{Contractor workhours scheduled by craft}}{\text{Contractor workhours worked by craft}}$	Percent	Indicates how effectively contractors are being utilized on planned work; the balance may be either emergency work or to avoid overtime by direct employees.
6	$\frac{\text{Contractor overtime workhours by craft}}{\text{Contractor regular time workhours by craft}}$	Percent	Indicates level of contractor overtime.
7	$\frac{\text{Contractor cost}}{\text{Contractor workhours worked}}$	Dollars per workhour	Gives a cost per workhour for estimating purposes and comparision with cost of organization's manpower. The difference between the two indicates the premium being paid to contractors for the privilege of adjusting staff levels to immediate demand.

Figure 2-14

Material Control Indicators

No.	Index	Units	Comments
1	$\frac{\text{Requisitions filled from stock without delay}}{\text{Total requisitions received}}$	Percent	
2	$\frac{\text{Requisitions not filled due to stockout}}{\text{Total requisitions received}}$	Percent	
3	$\frac{\text{No. of stocked-out items causing lost production}}{\text{No. items not filled due to stockout}}$	Percent	Nos. 1, 2, 3 and 4 measure service factor of materials supply function.
4	$\frac{\text{Value of lost production due to stockouts}}{\text{Value of scheduled production}}$	Percent	
5	$\frac{\text{Value of maintenance material inventory}}{\text{Value of facilities (replacement cost)}}$	Percent	Nos. 5, 6, 7, 8 and 9 are indicative of the cost of providing the service reflected in nos. 1, 2, 3, and 4.
6	$\frac{\text{Value of spare parts inventory}}{\text{Value of maintenance material inventory}}$	Percent	The two groups must be balanced at a satisfactory level.
7	$\frac{\text{Cost of operation of materials supply}}{\text{Value of materials issued}}$	Percent	Indicates overhead charges applied to materials issues; will vary widely due to accounting practices.
8	$\frac{\text{Cost of operation of materials supply}}{\text{Value of materials inventory}}$	Percent	When the numerator of no. 8 includes the current interest rate applied to the value of the inventory, the ratio reflects the total inventory carrying cost; will average 25 to 30 percent per annum.
9	$\frac{\text{Value of materials issued}}{\text{Value of materials inventory}}$	Percent	No. 9 indicates the stock turnover rate or activity and average age of materials in inventory. General materials should have an average turnover of 3 to 4 times per year and are controlled by normal inventory control practices. Spare parts turnover should average about 2 years, the greater the turnover, the greater the risk of stockout, delayed repairs, and lost production; lower turnover produces inflated inventory levels.

Figure 2-15

Organization Control Indicators

No.	Index	Units	Comments
1	Average no. of plant engineering workers Value of facilities (replacement cost)	Number per $1,000	Reflects staffing level and service demand relative to size of plant to be maintained.
2	Annual no. of plant engineering workhours worked Value of facilities (replacement cost)	Workhours per $1,000	
3	No. of plant engineering craftsmen No. of plant engineering foremen	percent	Will vary between 6/1 and 12/1. Proper level varies widely by craft.
4	No. of plant engineering craftsmen No. of plant engineering supervisors (2nd line)	Percent	Will vary between 1/20 and 1/40.
5	No. of plant engineering craftsmen No. of planners and schedulers	Percent	Will vary between 1/20 and 1/40. One schedular can normally handle the work of 2 to 4 planners.
6	No. of plant engineering craftsmen No. of plant operators	Percent	Reflects relative rates of adoption of new technology.
7	Plant engineering payroll cost Total plant engineering cost	Percent	Reflects balance between labor and material costs.
8	Plant engineering payroll cost Plant engineering payroll cost	Percent	Reflects cost of special services with inflation and advancing age and seniority.
9	No. of new workers hired by craft No. of workers terminating by craft	Percent	Level of replacement planned should consider vacation earned, retirement, resignations, average age, availability of replacements, apprentice training, work force utilization, workload demand, and contractor policy.
10	No. of instrument loops No. of instrument workers	Number per worker	Indicative of demand for maintenance services per available qualified craftsman.
11	No. of electric motors No. of electricians	Number per worker	
12	No. of rotating equipment items No. of mechanics	Number per worker	

Figure 2-16

Equipment Control Indicators

No.	Index	Units	Comments
1	$\frac{\text{Annual plant engineering cost by equipment type}}{\text{Replacement cost by equipment type}}$	Percent	Will reflect cost of plant engineering as function of equipment age and conditions.
2	$\frac{\text{Failure repair workhours by equipment type}}{\text{Total plant engineering workhours by equipment type}}$	Percent	Gives indication of effectiveness of plant engineering efforts by equipment type or class.
3	$\frac{\text{Preventive maintenance workhours by equipment type}}{\text{Total plant engineering workhours by equipment type}}$	Percent	
4	$\frac{\text{Overhaul and turnaround workhours by equipment type}}{\text{Total plant engineering workhours by equipment type}}$	Percent	
5	$\frac{\text{Downtime caused by equipment type, hours}}{\text{Total plant downtime, hours}}$	Percent	
6	$\frac{\text{Total operating time by equipment type, hours}}{\text{Total number of failures by equipment type}}$	Hours per failure	Mean time between failures by equipment class.

Figure 2-17

Cost Control Indicators

No.	Index	Units	Comments
1	$\frac{\text{Plant engineering cost by product, dollars}}{\text{Total production by product, 1,000 lb}} \times 10$	Cents per pound	Portion of product manufacturing cost due to plant engineering. Also useful for utilities supplied internally.
2	$\frac{\text{Total plant engineering cost}}{\text{Facility value (replacement cost)}} \times 100$	Percent	Varies according to complexity of processes and severity of conditions, runs 2 to 3 percent for refineries, 4 to 5 percent for petrochemicals.
3	$\frac{\text{Direct plant engineering labor cost}}{\text{Direct plant engineering materials cost}} \times 100$	Percent	Reflects utilization of available workhours and policy of "replace" vs. "repair" of equipment components.
4	$\frac{\text{Total workhours worked}}{\text{Total workhours paid}} \times 100$	Percent	Utilization of available workhours on work orders.
5	$\frac{\text{Actual cost per work order}}{\text{Estimated cost per work order}} \times 100$	Percent	Variances in excess of \$200 or 10 percent require explanation.
6	$\frac{\text{Actual cost per work order}}{\text{Budgeted total plant engineering cost}} \times 100$	Percent	
7	$\frac{\text{Total labor cost (company and contract)}}{\text{Total workhours labor cost}}$	Dollars per hour	Cost per workhour of actual work on work orders.
8	$\frac{\text{Cost of planning and scheduling}}{\text{Total plant engineering labor cost}} \times 100$	Percent	Should range from 4 to 6 percent.
9	$\frac{\text{Cost of plant engineering supervision}}{\text{Total plant engineering labor cost}} \times 100$	Percent	Should range from 15 to 20 percent.
10	(Direct plant engineering cost) + (cost of downtime) + (cost of deferred work) = total cost due to plant engineering	Thousands of dollars per year	Should be balanced against service factor of facility to determine the optimum balance between the two.

Figure 2-18

Overall Performance Indicators

No.	Index	Units	Comments
1	$\frac{\text{Total costs due to plant engineering}}{\text{Total sales of plant production}}$	Cost per dollar	Numerator from No. 10, Figure 2-17, indicates plant engineering costs from a director's viewpoint.
2	$\frac{\text{Value of lost production due to downtime}}{\text{Value of scheduled production}}$	Percent	Evaluates service factor slippage: runs 0.5 to 1.5 percent for most industries. High premium on a low value only if lost production could have been sold.
3	$\frac{\text{Total costs due to plant engineering}}{\text{Total after tax earnings}}$	Percent	Will range between 0.8 and 1.2 for most companies.
4	$\frac{\text{Total costs due to plant engineering}}{\text{Total conversion cost}}$	Percent	Total conversion cost is the total manufacturing cost less the cost of raw materials. Will vary widely from industry to industry, but is relatively constant for a given plant.

Observation and Evaluation

Effective control should not start with reports. They help, but it is difficult to design them to tell the whole story. The first and most important form of control is exercised when managers walk their campuses, objectively observing and evaluating the condition of the buildings, equipment, and grounds. When they observe personnel at work and evaluate their productivity, when managers listen to and analyze the complaints received from the campus community, when they see and question how much emergency versus planned and routine work is done, and when they see the wise or indulgent use of energy, managers learn much about the organization's performance.

Observation and evaluation such as this set the overall level of expectation against which actual results can be compared. If this is not done first and continuously, other control measures can lose their relevancy. Some may argue that management expectation is part of goalsetting, which is in turn a part of planning—not control. While this may be true in theory, in practice many plans are not fully understood until they are interpreted. The communication of management expectation is a way of interpreting plans, and this frequently occurs after the plans have been put into effect.

Organizing for Control

Effective control can be enhanced by the way the plant department is organized. Certain basic elements should exist in any department that is under good control, regardless of its size. Some of the most important elements are:

- Building and Equipment Inventory provides factual information on what is to be maintained and replaced when needed.
- Maintenance Standards define the level of maintenance expected. Certain facilities—because of their age, use, or budget restrictions—may be deliberately maintained at a minimum level. Other facilities may require the highest level possible with no compromise. Whatever the level, it should be defined in writing to avoid false expectations.
- Work Classifications indicate how work will be handled. The types of work done by physical plants are so varied that one system for organizing all work is not usually adequate. For example, a different approach is needed for emergency equipment repairs than for routine housekeeping. The eight work classifications developed by the Department of the Navy are useful:

  Emergency work.
  Service work.
  Minor work.
  Specific jobs.
  Standing jobs.

Supplements to authorized work.
Amendments to authorized work.
Rework.[7]

Small institutions do not need this many classifications. Perhaps four would be enough: emergency, routine, standing, and non-productive. The number of classifications and what they are called is a matter of individual choice.

- Numerical Identification marks each item in the inventory. This makes it much easier to collect historical information on work done for each item. In well-developed systems, all work done is also slotted and collected in various categories, each with a numerical identity. For example, any kind of heating, air conditioning, or control system repairs might be collected in a category called HVAC Repairs. This allows for gathering data such as Building Number 13 had $8,000 worth of HVAC repairs in the last two years; or 2,000 workhours were required last year for pruning all plants on campus.
- Work Order Systems were discussed earlier in this chapter. A good work order system is one of the basic elements of control.
- Material Coordination is vital to control and difficult to establish. (See Chapter 5, "Management of Maintenance Stores.")
- Shop Scheduling. Small plants need a system of daily scheduling of individual workers. In larger organizations weekly scheduling and master scheduling are mandatory.

Many organizations, from the smallest to the largest, create a separate department whose primary responsibility is to install and administer the above control elements. These departments are frequently given the name Work Control Center. These control centers are often assigned the following types of duties:

- Administration of the work request system.
- Job planning and scheduling.
- Material coordination.
- Estimating, including establishment of labor and material standards.
- Developing, monitoring, and analyzing the preventive maintenance program.
- Performance measurement, including management reports.

Once management's expectations have been communicated and the basic organizational elements are in place, meaningful reports can be designed and generated. Some of the most useful types of reports will be discussed.

Cost Control Reports

Cost control reporting usually takes two forms. The first are accounting-oriented reports. These cover budget versus actual costs for the total physical plant, or its major subdivisions, on such items as salaries, materials, supplies, utilities, equipment, fringe benefits, and other such accounts. Top administrative managers are the main users of this information.

The second type of cost reports are job cost reports that show all actual material and labor charges made to individual jobs. Superintendents, supervisors, and foremen usually find these more useful. Job cost reports often show the estimated material and labor so that an actual versus estimated appraisal can be made.

The job cost report is frequently prepared in two formats. One format, called Work in Progress or Jobs in Progress, shows all the charges made to each job as of a certain date. This information helps supervisors know—while the job is progressing—whether the work will meet, beat, or exceed the estimate.

The other common job cost report format is a periodic report on completed jobs. This report gives the final comparison of actual versus estimated charges. All jobs appearing on this report are completed and no additional charges can be made to them. Reports such as this are usually issued monthly and contain all jobs closed out during a given month. At large institutions with a high volume of work orders, it may be necessary to prepare this report more often than monthly.

Both of these job cost reports are effective aids for control. For example, the Jobs in Progress report is useful in the following ways:

- There is a relationship between the number of jobs being performed and the number of new jobs issued each month. If 15 new jobs are issued each day and the average time for completion from date of issue is 25 days, then the number of jobs in progress at any time should be 375 (15 × 25). If 600 jobs appear on the report, something is wrong or at least abnormal. Possibilities are a bottleneck in one or more shops, an abnormally high influx of jobs, slow processing of paperwork in closing out jobs, or a disproportionately high number of large jobs that raise the average time for completion above 25 days. Whatever the cause, use of this report for control begins when managers and supervisors start questioning the high number of jobs in process.
- The appearance of many old jobs on the report could mean there is a problem with shop capacity, material delivery, change orders, or lost paperwork.
- A review of actual charges to date versus the estimates can be an early warning of jobs that are in trouble. If a job is 50 percent complete, but 90 percent of the money or estimated hours have been spent, something is probably wrong.

The job cost report for completed work is also an effective control tool:

- This report identifies the relationship between the number of new jobs issued and the number of jobs completed. Obviously, over a period of time, the number of jobs completed should equal the number of jobs issued. This is elementary but it can be overlooked if reports are not available. If fewer jobs are being completed than being issued, a bottleneck exists somewhere in the system that needs management's attention.
- The completed jobs report is the main source of information on job performance versus estimates. Large variances can mean poor performance, poor accounting of charges, poor estimating, or insufficient planning.
- The completed jobs report can also serve as a fundamental data base on the characteristics of the plant's work flow. The report can help managers classify work into different systems for the different types of jobs that are encountered. Analysis of completed jobs might show that 75 percent of a shop's manpower is spent on jobs that have a labor content of 24 to 32 hours or more. This factual information could affect the design of a scheduling system or allocation of shop manpower.

Equipment Failure Reports

Equipment failure reports are generated from records produced by the basic system. The work order system and the job cost system collect historical information on work done to the items in the building and equipment inventory. This is accomplished by classifying the work into categories and keeping records of work done using building and equipment identification numbers. In small institutions it may be perfectly adequate to keep a simple data card on each item and simply write down any significant work done to the item.

Equipment failure reports are the result of manual or computer-assisted analysis of the costs resulting from maintaining the inventory items. Ideally, the highest cost items can be easily identified each time the report is prepared. If this is done, the equipment failure report serves its purpose to management.

Use of the information produced by this report can be extensive. Two basic questions the report raises are: Why is failure occurring—inherent design weakness, abuse, poor maintenance workmanship, or lack of preventive maintenance? and, When is it time to stop repairing the item and seek replacement? Reports do not directly answer these questions, but reports do enable conscientious managers to ask more insightful questions (evaluate) and generate action (plan) to obtain the answers.

Labor Productivity Reports

Any measures of productivity attempt to relate output to the effort required to obtain that output. In labor productivity reports, output is usually stated in terms of planned or estimated workhours. The effort required to produce this output is simply the actual workhours spent. Productivity is usually defined as the ratio of planned or estimated workhours to actual workhours.

If a basic work order system is in place and estimating of at least large jobs is done, labor productivity can be easily measured on a job-by-job basis. For example, if a job was estimated to take 56 workhours and it actually took 60 workhours, the productivity is 56 divided by 60, or 0.93. If the job only took 54 workhours, the productivity would be 1.04 (56 ÷ 54).

Since the report on completed jobs (discussed previously) contains the data needed for a productivity calculation, productivity indexes are often included as a part of this report. Using this report allows not only the calculation of productivity on each job, but also the calculation of a total productivity figure that includes all jobs completed in a given month.

In the strictest terms, it is not sufficient to include only the mechanic's, custodian's, or laborer's time in the actual time spent on a job. This does not give a true picture of labor productivity, because it fails to recognize other labor inputs required to complete the job. What about the efforts of the foreman, the materials manager, and the engineer who designed the job? What about the time spent for training, rework, planning, and other indirect activities? A true productivity measure for the total department must include all these indirect, yet important, efforts that support the employee working directly on the job.

While the completed jobs report, showing actual versus estimated performance, is one of the best productivity reports, other types of labor measurement are also useful. Other reports often used include backlog, labor utilization, overtime, and absenteeism reports.

Backlog Report Backlog reports try to measure how much known work remains undone at any point in time. The amount of known work remaining is stated in terms of total workhours.

While it is important to be able to track the total workhour backlog, managers usually find it more meaningful to think of backlog in terms of the number of days, weeks, or months worth of work represented by the total workhour backlog figure. To do this they relate the workhour backlog to their workhour capacity.

If a shop has 5 employees, its workhour capacity (in simplest terms) is 200 workhours per week (5 employees × 40 workhours/week/employee). If the total work remaining unfinished for that shop is estimated to be 6,000 workhours, the backlog is 30 days (6,000 workhours ÷ 200 workhours/week). If one employee goes on extended sick leave, the shop capacity drops to 160 workhours per week and the backlog increases to 37.5 days (6,000 ÷ 160).

In more refined systems, managers are not satisfied with calculations as simple as these. The main adjustment they make is in calculating shop capacity. They know that employees are not productive 40 hours a week, so they attempt to determine what percentage of time is actually productive in their organization. Managers usually settle on a capacity per employee of 6.0 to 7.5 hours per day, or 30 to 37.5 workhours per week per employee. Using the lower figure in the above example, the 6,000 workhour backlog would now represent 40.0 days worth of work (6,000 ÷ 150 workhours/week). Work sampling, discussed in Section 2.9, is an effective technique for determining the productive percentage of an employee's time.

More accurate backlog calculations do not become too important until schedulers start using backlog figures to quote promise dates for starting new jobs. Until that time it is best to keep the calculations simple and consistent so that trends can be seen.

In more complex systems, additional detail on the composition of the backlog is contained in the report. For example, managers would know that the 6,000 workhour backlog in the preceding examples had the following breakdown:

Jobs in progress	1,500	workhours
Jobs awaiting material	2,500	workhours
Jobs awaiting scheduling	2,000	workhours
Total	6,000	workhours

The true backlog of available work is now known to be 3,500 workhours (jobs in progress plus jobs awaiting scheduling); 2,500 workhours of the 6,000 workhour backlog is awaiting materials on order.

Backlog reports can be a control tool in the following ways:

- The reports let management know if the employees are getting ahead, getting behind, or staying even with the work.
- They guide decisions on which shops are over- or under-staffed.
- The reports help determine when outside contracting is needed, and how much.
- They assist schedulers in informing customers when new jobs can be started.
- They point out bottlenecks such as slow material specification, ordering, or delivery.

Labor Utilization Report This is one of the most basic and most useful labor reports. It is simply a breakdown of how a physical plant's total hours are spent. The report divides total payroll hours (or dollars) into various predetermined classifications such as productive work, rework, lost time, vacation, paid sick leave, training, meetings, and breaks. In the best systems there is complete reconciliation between this data and the payroll.

This report is prepared from the daily time sheets filled out by each employee. The labor utilization report does not show productivity per se. It simply shows how employees are spending their time without trying to relate this to work output. The report is nevertheless useful for determining—

- Proportion of total hours spent on work orders. (This can be compared to the planned proportion.)
- Amount of lost time occuring.
- Actual workhour capacity for productive work— for use in scheduling.

Overtime Report These reports show the number of hours spent for which a wage premium, or other type of penalty, is paid. Overtime reports often express overtime hours as a percentage of total workhours, which can be a more meaningful control index.

The existence of some overtime should not necessarily be considered a sign of poor control. Overtime within a range of 5 percent of all regular hours worked is usually acceptable. More overtime than this starts to reflect on the organization's ability to plan and schedule work. Less than this could indicate an excess of manpower.

Absenteeism Report The level of absenteeism is an important indicator of how employees view the personnel policies, as well as how tightly or loosely the policies are administered by supervisors and managers. Monitoring absenteeism for this purpose is basic to personnel management.

Absenteeism reports should also be used by planners and schedulers for helping determine workhour capacity and manpower requirements. If a certain task, such as preventive maintenance, requires 3,850 workhours per year to perform, absenteeism figures help determine the number of employees required.

Gross hours available from each worker each year (40 hours/week/person × 52 weeks/year)	2,080
Less: Absenteeism and nonwork time	
Vacation (10 days)	(80)
Sick (assume 5 days or use past records)	(40)
Holidays (10 days)	(80)
Nonwork time (e.g. meetings, training, lost time—25 days)*	(200)
Net available hours per person per year	1,680

Number of employees required: 3,850 + 1,680 = 2.3 employees

*This figure can be obtained from the labor utilization report.

2.9 WORK SAMPLING

Most efforts to control labor costs have focused on that part of an individual's day when he or she is doing productive work—sawing, measuring, drilling, sweeping, pruning, etc. Labor standards for these activities have been established time and again, and systems have been used to measure how productive this effort is. This approach was used because productive time is the largest part of an individual's day.

In recent years, however, increasing interest has been shown in trying to determine how the nonproductive portion of an individual's day is spent. Even where sophisticated work measurement and control systems are in place, only about 70 percent of an individual's day is spent on productive work. Management is now becoming more concerned with how the balance of a worker's time is used. Work sampling is a relatively inexpensive and effective way to gather this factual information.

Theory of Work Sampling

Work sampling is based upon the idea that if enough samples are taken at random from a large group, analysis of the samples will exhibit characteristics that are close to those possessed by the group as a whole. Sampling of any kind is a way of accurately estimating certain features of a large group or population without examining each item in the entire population.

The population in plant management consists of all the events, which, when strung together, constitute an individual's work day. Work sampling looks at only a few of these events and draws conclusions about all of them taken in aggregate. If the correct procedure is followed, the conclusions will be accurate.

To illustrate using a nonwork example: If you want to know fairly accurately how many television sets in the United States are tuned to CBS on Tuesday at 8:00 P.M., it is not necessary to check every set. By checking only a few (about 1,500) at random and determining what percentage of these are tuned to CBS, you can estimate with high confidence that the same percentage (give or take a little) of all televisions in the United States are tuned to CBS. This is what A. C. Nielson Co. does each week to determine the viewing preferences of millions of Americans.

Taking samples, examining them, and drawing conclusions about the entire group is called statistical inference. The theory of statistical inference will not be discussed here, but can be found in any basic statistics textbook. One need know little about statistical inference theory to use work sampling successfully. All a manager needs is to understand the basic idea outlined above and the principles that follow.

Principles and Concepts

Suppose a manager wants to determine the proportion of time that one or more employees spend working and the proportion of time spent not working. This could be done by observing and timing them all day for a number of days. However, this would be time consuming, expensive, and the manager would be uncertain the days chosen for observation were representative of typical days.

Suppose, instead, that a large number of instantaneous, random observations were made to determine whether the employee was working or idle, and then the results were tallied. The tally sheet would probably look like Figure 2-19.

The percent of the tallies under Working is an estimate of the actual percentage of time employees spend working. The estimate is not an extremely accurate picture of how people *always* spend their time because relatively few observations were made. If more observations were taken, the accuracy of the estimated percentage would be higher.

How many observations are required? This depends upon how precise and confident we want to be in our answers. The more precision and confidence we want, the more observations we will have to make.

Figure 2-19

Simple Observation Tally Sheet

Category	**Tally**	**Number**	**Percent**
Working	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍷𝍷	82	73%
Idle	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍷	31	27%
Total		113	100%

Statisticians have studied the relationship between the number of observations, precision, and confidence level and have published their results in graph form. Figure 2-20 is a graph for determining the number of observations required.[8]

- The graph is for a confidence level of 95 percent. This means that we can be 95 percent sure of the information we take from the graph. If a higher or lower confidence level is desired, this graph will not be applicable. However, for most work sampling a 95 percent confidence level is satisfactory.
- Before using the graph a rough estimate must be made of the percentage of time expected. This means managers must guess at the percentage their study is being conducted to find. Make an educated guess based on a ballpark percentage, or run a short study of relatively few observations such as Figure 2-19.
- Before using the graph choose the acceptable level of precision, the confidence interval. Determine how accurate the results must be. For example, if the work sampling study shows idle time is 30 percent, is that 30 percent plus or minus 1 percent, 30 percent plus or minus 2 percent, or 30 percent plus or minus 10 percent? The curve chosen from Figure 2-20 depends on the acceptable degree of error.

Having considered the above factors, a typical plant administrator is satisfied with a 95 percent confidence level, and runs a short check study, such as shown in Figure 2-19. Furthermore, he or she decides to be fairly precise and chooses an acceptable error of plus or minus 1.5 percent. The administrator is ready to use Figure 2-20 to determine how many observations are needed to check the amount of idle time of employees.

Based on the initial research, idle time is in the neighborhood of 31 percent. To use the graph, find 31 percent on the abscissa (x-axis), then move up to the curve labled "Error, plus or minus 1.5 percent." Read across to the ordinate (y-axis) for the number of observations required—about 3,800.

This determines that about 3,800 observations are required to be 95 percent sure that the results of the study are accurate to within plus or minus 1.5 percent.

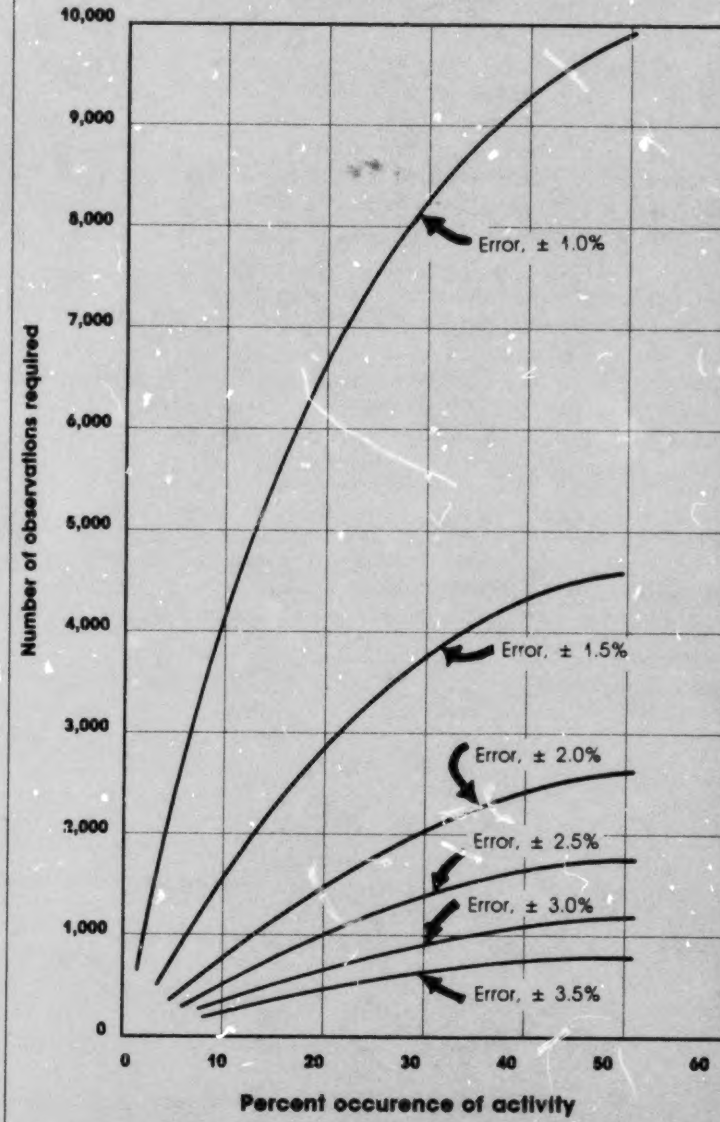
Note how rapidly the required observations increase as demand for precision increases. If an error of only plus or minus 1 percent is required, many more observations are needed—about 8,500 instead of 3,800.

Procedure for Conducting a Work Sampling Study

The basic procedure for conducting a work sampling study follows. More detailed procedures and discussion relating specifically to university physical plants can be found in the papers of L. Terry Suber and Paul Loopo of Colorado State University.[9]

Figure 2-20

Graph for Determining Number of Observations Required (95% Confidence Level)



A shop has 10 employees. We want to determine their work time, delay time, and personal time. The procedure would be as follows:

Design the Work Sampling Study First estimate the preliminary values for the percent of time spent in the three categories of interest—work, delay, and personal. This can be done through educated guessing or through a check study (Figure 2-19). The preliminary estimates are—

Work	85 percent
Delay	10 percent
Personal	5 percent

Then choose the level of precision and confidence—say plus or minus 1 percent with 95 percent confidence. In other words, we decide that if the estimate for delays is actually 10 percent, we want to be 95 percent sure that it is not less than 9 percent or more than 11 percent.

Determine the number of observations required. From Figure 2-20 we see that 3,600 observations are needed for the desired level of precision and confidence.

Select the period of time over which the observations will be made. Observations spread over a two-week period (10 work days) will be representative of typical conditions. Then plan to take 360 observations per day (3,600 ÷ 10). Since there are 10 employees involved, we will obtain 10 observations each time we sample. Therefore, we need to program 36 random observation times each day for 10 days to obtain our required 3,600 observations. The easiest way to obtain 36 random times is to use a random number table. (These tables are available in almost any text on statistics as well as in the Suber and Loopo papers.)

Plan the mechanics of conducting the study. This includes preparing forms, selecting the route to follow or the method of finding the employees, selecting and training the observers, and communicating to the employees what is happening and why.

The above procedure is a general description that does not cover the subject completely. Many precautions must be taken: ensure randomness, train observers, select the activities to be studied, and communicate intentions and results to those involved.

Interpreting and Using the Results

Work sampling studies are usually performed for one of two reasons. Managers suspect that much lost time is occurring, but they have no factual information on the type or amount. The objective in this case is to identify the major categories of lost time and the relative proportion of each. In the second situation lost time is not considered excessive, but managers want to know what percentage of employees' time is productive in order to improve estimates and scheduling. The former is the most common objective in physical plant work sampling studies. The latter is less common because it represents a fine tuning of systems that are already in good order. For simplicity's sake the example presented above represents a study geared more to the second objective—fine tuning. Managers usually want to obtain more detail on delays and personal time than what this example gave. A more realistic breakdown of categories for actual use would be—

Working time
Delay, tools or equipment
Delay, transportation
Delay, instruction
Delay, another trade
Delay, at warehouse
Talking, with foreman
Talking, with staff
Talking, with other workers
Travel, to or from job
Travel, for tools or equipment
Travel, for material
Travel, for transportation
Travel, for instruction
Idle
Late start
Early quit
Personal
Injury
Meetings or training

Interpretation and use of the results must be determined at the beginning of the study when categories are selected and defined. Results are easier to interpret if detailed categories such as those above have been used, rather than the broad categories used in the example. If the study is properly designed and conducted with a level of detail similar to that given above, results are fairly easy to interpret and use.

For example, if large delays are occurring at the warehouse, perhaps the warehouse is not manned properly, does not have a good location system for finding materials, or does not carry the right amount or kind of stock. Or if excessive travel for instructions is occurring, the following areas may need investigation: better initial job instruction, more use of radios and telephones, preliminary inspection of the job site before work begins, and more detailed estimates and plans.

Work sampling will not in itself produce solutions to problems. It is not a problem solver as such. But it is a tool for identifying problem areas and for giving managers information that will enable them to ask questions they may not have asked before.

Managers need not be statisticians to do effective work sampling. Nor is it absolutely necessary to have a thorough understanding of normal distributions, confidence levels, confidence intervals, standard deviations, probability theory, etc. There is enough information available here to conduct work sampling and benefit from the resulting information.

2.10 CONCLUSION

This chapter has introduced and explained new methods of managing the maintenance task of a large or small plant department. The use of these techniques should enable the plant administrator to know his or her organization better, and provide a solid foundation for the reduction of costs while increasing productivity.

Tightening budgets, funding competition, and aging facilities make it essential that the facilities department of any college or university be operated in the most efficient manner possible to get the greatest return for every dollar invested. Good maintenance planning, scheduling, and management will help accomplish this task.

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CHAPTER 3

Preventive Maintenance

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3.1 INTRODUCTION

The words *preventive maintenance* are being used by engineers and plant directors across the United States. Preventive maintenance in itself is not a new concept. It has been around in manufacturing plants for years. The United States Air Force became an early champion of a rigorous preventive maintenance program when it started placing intercontinental ballistic missiles in silos around the countryside. Many of these silos were well over 100 miles from their support base over rugged terrain that was sometimes impassable during periods of adverse weather. It was apparent to the planners that the old maintenance concept—fixing something when it broke—could not keep the missiles force on alert. Only with a preventive maintenance program, coupled with a mandatory time change or replacement program, could the necessary requirements be met.

As work forces become smaller and costs continue to increase, each department must operate in the most efficient and economical manner possible. Waiting for something to break and attempting to fix it—sometimes in a makeshift manner—is certainly not an acceptable means of operation. Although a certain amount of breakdowns cannot be avoided, a preventive maintenance program will reduce these breakdowns to a minimum.

Some believe that only larger institutions need, or can afford, a preventive maintenance program. Regardless of the square footage or budget, a preventive maintenance program can be a definite benefit to any type or size of educational facility. The key is to fit the program to the needs of the institution.

Definition

The term preventive maintenance is not new, although it may be to some college and university administrators. General agreement can usually be be reached on what constitutes the elements of a preventive maintenance program; however, there are many definitions of what the program is. Preventive maintenance is defined here as a program in which wear, tear, and change are anticipated and continuous corrective actions are taken to ensure peak efficiency and minimize deterioration. It involves a planned and controlled program of systematic inspection, adjustment, lubrication, replacement of components, as well as performance testing and analysis.

Surveys of many colleges and universities concerning the scope of their preventive maintenance programs resulted in answers such as—

> "We have two full-time lube men."
> "We inspect our equipment on a regular schedule."
> "We schedule equipment downtime for preventive maintenance every week."
> "Our mobile equipment is serviced routinely."

In some cases, the term *planned maintenance* is synonymous with preventive maintenance, but it may also include such repetitious work as general lamp replacement and annual overhaul procedures. Preventive maintenance includes cleaning, adjustments, lubrication, minor repairs, and parts replacement. All are performed on scheduled frequencies (weekly, monthly, quarterly, semiannually, or annually) in accordance with written maintenance instructions.

Philosophy and Role of PM

Preventive maintenance (PM) is a state of mind. For a preventive maintenance program to be effective, it must be fully understood and wholeheartedly supported from top management on down through the work force. If the individuals performing the work do not understand and believe in the program, it will not be successful. Historically, when workloads become heavy, it is the preventive maintenance program that is first cut back. Over time this treatment will lead to the elimination of any effective program.

When considering a PM program, questions often asked are: What percentage of the labor force should be used in the preventive maintenance program? How many workhours will it take? and, How many dollars should be spent in carrying out a preventive maintenance program? The best answer is, Whatever is enough. Once managers determine what equipment to place in the program and the type of inspection to perform, the cost in dollars and workhours can be calculated. Although at first glance the requirements may seem excessive, the plant director must balance program requirements with available resources in order to implement the desired program.

Benefits and Objectives

A successful preventive maintenance program produces many benefits—almost all of which are some type of cost savings. One of the primary objectives of a PM program is the reduction in downtime of critical systems and equipment. Obviously, some downtime is unavoidable, even in the performance of preventive maintenance tasks themselves. It is the unscheduled downtime that causes major problems, and which can be reduced to a bare minimum. A good preventive maintenance program extends the life of the facilities and equipment. It also improves equipment reliability. Preventive maintenance will ensure that equipment is operating properly (at the right speed, temperature, etc.), which will reduce energy consumption and, in some cases, improve safety by identifying and correcting quickly unsafe conditions. Building preventive maintenance will also improve the overall appearance of the facilities, thus improving the image of the institution and the physical plant department, since unscheduled breakdowns are held to a minimum.

Economics of PM

As mentioned above, a successful preventive maintenance program will produce cost savings. The cost of scheduled repairs is significantly less than the cost associated with major breakdowns. As illustrated in Figure 3-1, the initial cost to implement a preventive maintenance program will be more than current maintenance costs. Over time, as the effects of the preventive maintenance program are realized, there will be a cost savings. Because more work is performed on a scheduled basis, there will be less overtime and greater maintenance labor productivity. This means a reduction in staff can be realized even though the preventive maintenance program is in addition to current workloads. Depending on the size of the facility and the type of maintenance performed, outside contract maintenance and repairs should also decline as a result of the preventive maintenance program.

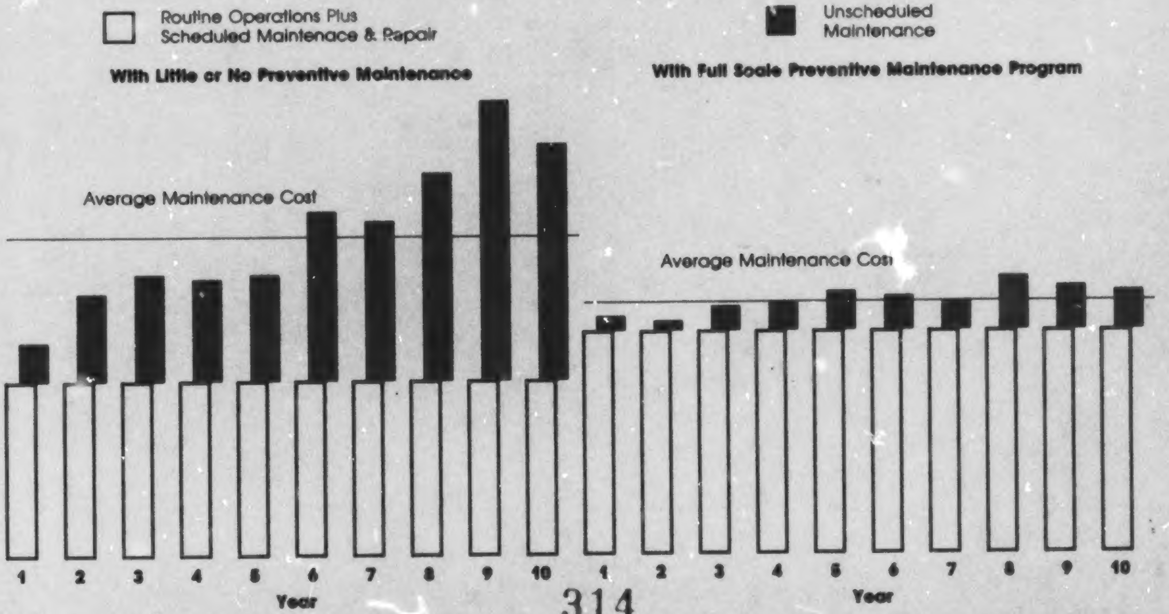
The improved system reliability will extend equipment life, thus protecting the capital assets of the college or university. This, in turn, will reduce capital outlays since equipment will be replaced less frequently. Reduced energy consumption will also affect overall costs. Finally, better management control of operating costs will be achieved since the majority of work will be performed on a scheduled basis and panic budgeting will be eliminated. The objectives of a preventive maintenance program will minimize equipment and system breakdowns and reduce total maintenance cost.

Basic Criteria for a PM Program

All preventive maintenance programs contain the same basic elements and develop in three basic phases: the planning phase, the implementation phase, and the operational phase. The planning phase is by far the most important phase and extremely time consuming. If individuals are available on a part-time basis, it may take as long as a year to complete the planning phase. Even if someone is assigned full-time, it will take several months to complete

Figure 3-1

Expected Economic Advantage of Preventive Maintenance (Inflation Affects Omitted)



all the steps required. During this phase a complete equipment inventory is established, the type and frequency of inspections are determined, a yearly schedule is developed, and the personnel are selected to perform the tasks.

The shorter implementation phase consists primarily of preparing and distributing work orders and the associated daily and weekly scheduling of work. The full magnitude of the preventive maintenance program as determined during planning should not be implemented at one time. This will be discussed in greater detail below.

The third phase is a continuing phase of preventive maintenance tasks. Important elements within this operational phase that must be closely monitored include an assessment of appropriate PM tasks, as well as proper frequency. Equipment grows old, uses change, and techniques vary. An effective preventive maintenance program is not static, but needs regular review and updating in order to remain viable and effective.

3.2 BASIC ELEMENTS OF A PM PROGRAM

The fundamental elements of a preventive maintenance program are preventive maintenance instructions, historical equipment records, feedback data, scheduling, and control.

Preventive Maintenance Instructions

Preventive maintenance instructions are those instructions or directions indicating specific tasks for the mechanic to perform on a given piece of equipment. These instructions must be specific enough to indicate what the mechanic should do or look for, and simple enough to be placed on a 5" × 8" card that the mechanic can carry to the job site (Figure 3-2). The frequency of inspections must be included in the instructions so the mechanic will know which particular tasks to perform on any given inspection.

Historical Equipment Master File

The historical equipment master file should be the central reference for all equipment for which the physical plant is responsible. Not only should it contain identifying data for each major piece of equipment and auxiliary items, but it should also include desired operating characteristics (Figure 3-3). The master file indicates when preventive maintenance was performed, any malfunction discovered, and the corrective action taken. Parts replacement must also be recorded in the master file in order to maintain a complete history of each item. This history helps determine costs and establish supply inventory levels (Figures 3-4—front and back).

Feedback Data

A preventive maintenance program is incomplete without a positive method for evaluating the results of the program. The feedback includes workhour

Figure 3-2

Preventive Maintenance Instructions

Equipment Name: ______________________ **Card No:** ____

Frequency of Inspection ______________________________

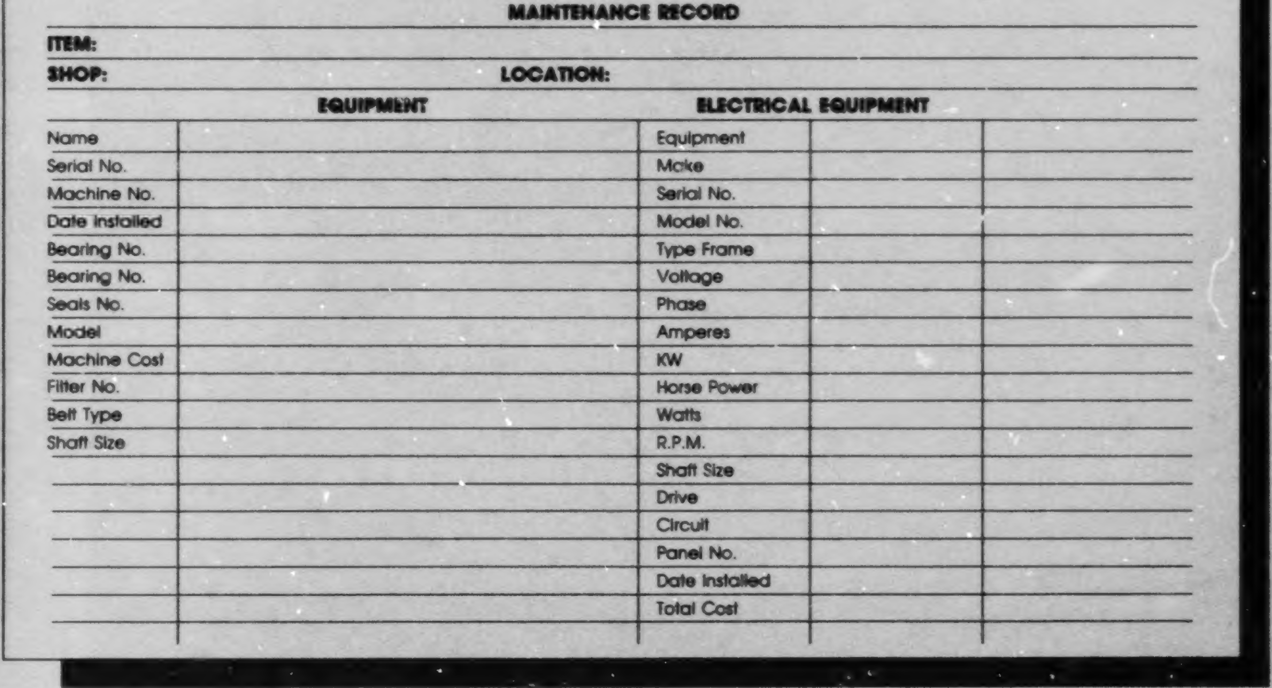
Shops & number of personnel required ________________

STEPS	M	Q	S	Y	TIME

Tools/Materials required:

Figure 3-3

Maintenance Record—Historical File



MAINTENANCE RECORD

ITEM:

SHOP: **LOCATION:**

EQUIPMENT		**ELECTRICAL EQUIPMENT**		
Name		Equipment		
Serial No.		Make		
Machine No.		Serial No.		
Date Installed		Model No.		
Bearing No.		Type Frame		
Bearing No.		Voltage		
Seals No.		Phase		
Model		Amperes		
Machine Cost		KW		
Filter No.		Horse Power		
Belt Type		Watts		
Shaft Size		R.P.M.		
		Shaft Size		
		Drive		
		Circuit		
		Panel No.		
		Date Installed		
		Total Cost		

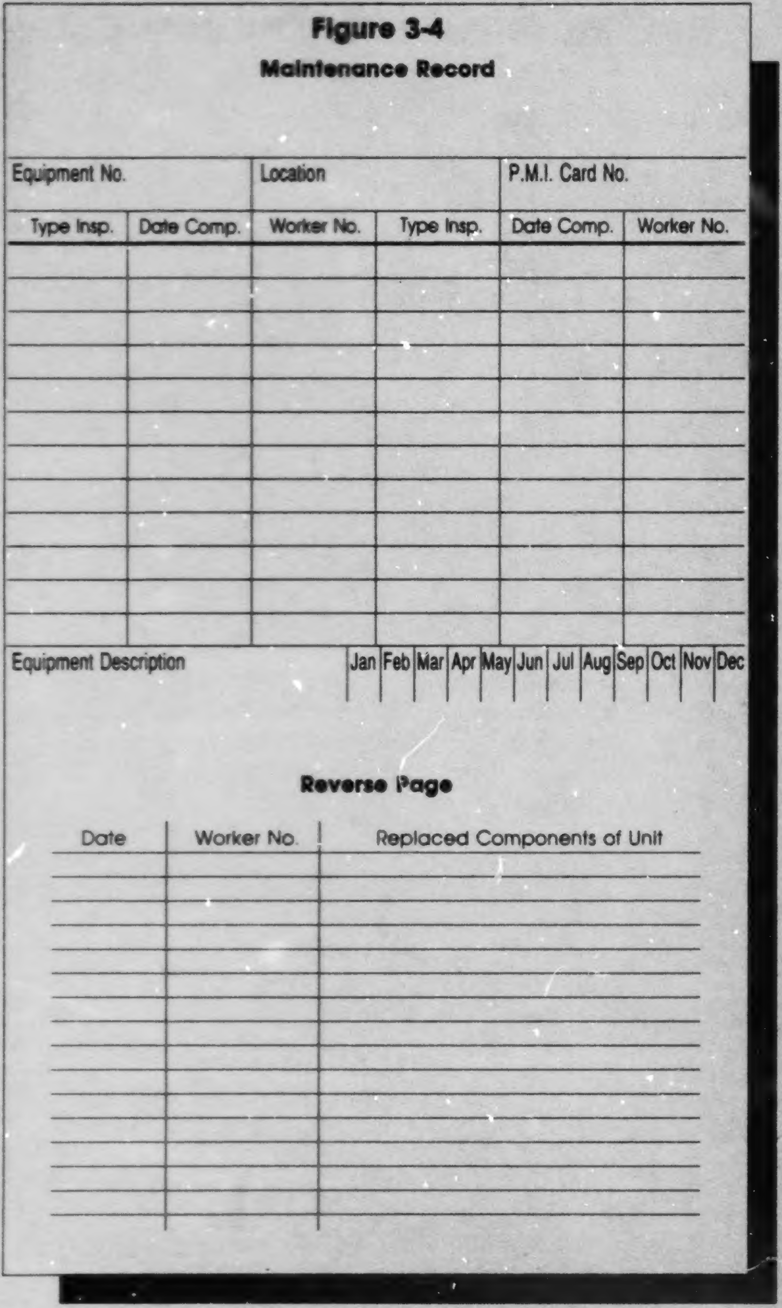


Figure 3-4

Maintenance Record

Equipment No.		Location		P.M.I. Card No.	
Type Insp.	Date Comp.	Worker No.	Type Insp.	Date Comp.	Worker No.

Equipment Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Reverse Page

Date	Worker No.	Replaced Components of Unit

and material requirements to maintain the program, as well as evaluation of the program's effect on emergency calls, equipment breakdowns and replacement, and overall improved maintenance scheduling and productivity.

There will always be equipment deterioration with subsequent breakdown or failure, as well as a certain number of breakdowns due to equipment defects. Since a preventive maintenance program will never eliminate this type of failure, there must be a distinction drawn between preventable and nonpreventable breakdowns. Analysis of the cause of equipment failure will reveal whether it was unavoidable or not. Some 40 percent of all equipment failure is due to weak components that probably could not be identified prior to the failure. The PM program is aimed at the other 60 percent that *can* be controlled.

Feedback may be useful in developing design requirements for new equipment. Design criteria may require the equipment to be more accessible for preventive maintenance tasks, or eliminate and/or improve parts that require excessive maintenance or have a high rate of failure. In addition, management will always ask what savings have been realized as a result of the preventive maintenance program. With feedback data these questions can be answered easily.

Scheduling

Implementing a preventive maintenance schedule into an already existing work schedule may require major adjustments in thinking and scheduling techniques. Prior to scheduling work orders, the entire work force must be thoroughly briefed on the intent of the preventive maintenance program, as well as the methods of implementation. To be successful a total preventive maintenance program must receive the support of everyone in the maintenance area, including those in the purchasing function. The purchasing staff is key because they normally prepare the purchase requests or bid documents that must include parts lists and the manufacturer's suggested PM program. Everyone's cooperation is especially vital if there is a union involved. Additional details for scheduling a preventive maintenance program are discussed in Section 3.5.

Control

The overall management of the preventive maintenance program should be under the control of one individual at a fairly high level within the plant department. The level of this individual is important for two reasons: to emphasize to everyone within the maintenance organization that the preventive maintenance program is important and will receive the director's attention, and to ensure that the individual has the authority—along with the responsibility—to manage the preventive maintenance program and supervise journeymen, mechanics, apprentices, and helpers from a number of different crafts.

3.3 EQUIPMENT AND FACILITIES TO INCLUDE IN PM PROGRAM

What should I include in the preventive maintenance program? The actual items that are included in the initial implementation of the PM program will be the result of an evaluation of needs and resources available. In all likelihood items will be added and deleted from the program on a continuing basis as needs and resources change from month to month and year to year. However, the initial list of equipment and facilities should be as broad as possible regardless of the resources available. Once the magnitude of the program is determined, equipment can easily be deleted. Be innovative in selecting items for inclusion in the program.

Inventory of Equipment and Facilities

Many administrators find that an accurate master equipment list does not exist within the plant department. A master list may be found in the accounting department, but if so, it will probably not be current. Now is the time to establish an equipment file that will be a single source of data, both static and dynamic, for each piece of equipment and/or facility the plant department maintains. To determine the accuracy of the equipment list someone must walk through all the facilities and look at the items.

After all the items are listed, an equipment numbering system must be established. In most facilities, a numbering system was initially used, but new equipment and buildings have been added and an update is sorely needed. The numbering system used should help a preventive maintenance worker locate a particular item. It will prove beneficial if a combination of letters and numbers identify the equipment location by building, floor, or equipment room. Remember to build in the ability to expand the system if more equipment is added in a particular location.

An excellent equipment numbering system is shown in Appendix 3-A. This system was developed by H. C. Lott, Jr., University of Texas at Austin. The numbering system not only identifies equipment, but also is used in the maintenance cost accounting system to segregate costs by maintenance classification and equipment item, subsystem, basic system, and building. With this system the maintenance manager can continuously review and analyze preventive, planned, and corrective maintenance; repair costs; and the relationships among them.

In addition to identifying location, the inventory should include a record of maintenance activities describing the work done; parts used and their cost;

characteristics of the equipment such as operating speeds, electrical requirements, etc.; manufacturer's name, location, manuals; suppliers of major components and parts; and some indication of preventive maintenance tasks required—either a list of the tasks or reference to a separate document containing these tasks. Preprinted forms are available for maintaining the records described above, or they may be developed in-house to meet specific user requirements (Figures 3-4 and 3-5).

It may be difficult to find some of the data necessary for the master equipment file. Data sources include equipment name plates, purchasing records, manufacturers' manuals and brochures, and workers' memories. It may be necessary to write the original manufacturer for much of the data needed or to call other facilities using the same type of equipment that have a record of the information. When new equipment is purchased, obtain the requisite information from the manufacturer at the time of installation, along with operating manuals and spare parts lists.

Analysis and Selection Process

In developing a preventive maintenance program, a manager may select items for inclusion in the program based on the number of breakdowns a particular piece of equipment has. Remember, some breakdowns and defects are unavoidable and would not necessarily change with preventive maintenance. But if one agrees that a preventive maintenance program is useful and necessary, then it follows that all equipment should be included. Three factors help determine which equipment to include: (1) the importance of the equipment to the functioning of the facilities, (2) the direct cost of equipment failure, and (3) the indirect cost of equipment failure. Ratings of importance for each factor range from 5 to 1. A priority score is obtained by multiplying the ratings of the three factors (Figure 3-5).

For example, a small air conditioner serving a computer area and having an estimated repair cost of $400 plus an indirect cost of $500 for unused labor and machine time loss might be scored as follows:

Factor 1	3
Factor 2	2
Factor 3	3

Priority Score = 3 × 2 × 3 = 18

A condensate pump might be scored:

Factor 1	2
Factor 2	2
Factor 3	3

Priority Score = 2 × 2 × 3 = 12

Figure 3-5

Guide to Setting Priorities for Preventive Maintenance

Factor 1	Factor 2*	Factor 3+
(5) Major basic facilities equipment critical to safety and functioning of entire institution. Boilers, electrical switchgear and distribution, emergency generator, water supply, fire alarms or fire fighting equipment.	(5) Over $1,000	(5) over $1,000 or serious injury.
(4) Equipment with direct relation to individual safety.	(4) $500 to $999	(4) $500 to $999
(3) Equipment essential to operation of department or major area. Air conditioning and ventilation systems, key laundry equipment walk-in refrigerators, dishwashers, key laboratory equipment.	(3) $250 to $499	(3) $100 to $499
(2) Equipment essential to smaller operations, for individual comfort or savings. Floor machines, machine tools, condensate pumps, business machines, conveyors, automatic doors.	(2) $100 to $249	(2) Less than $100
(1) Equipment not essential to operations but for comfort or convenience, for which many spares are available and individual replacement cost is low. Water coolers, small fans or ventilating equipment, small air conditioning units, carts, most furniture, television sets.	(1) Less than $100	(1) Essentially no cost

Score equipment by multiplying priority numbers of the three columns. Example: 2 × 4 × 2 = 16

*In using this column, estimate the magnitude of the cost of major repair or replacement, whichever is the case.

+In using this column, estimate the costs involved to the institution as a whole if the unit in question fails. This includes such things as overtime, lost time by employees, cost of alternative temporary solutions to the problems.

Source: *Hospital Engineering Handbook*. Third Edition. American Hospital Association.

Equipment with a priority score of less than a preset number probably cannot economically be included in a formal maintenance program. The preset number is determined by the available manpower plus funds and usually ranges from seven to nine. However, equipment with low priority scores should be maintained informally. For example, condensers should be cleaned, operation of water coolers checked, or small fans lubricated once a year. It may be most appropriate to send a repairperson around to check all such equipment items once a year during the summer, for example.

3.4 WRITING PM INSTRUCTIONS

One of the most difficult tasks in planning a preventive maintenance program is determining which preventive maintenance tasks the technician should actually perform and with what frequency. Too many tasks or too frequent performance will overload a preventive maintenance program and make its implementation impossible. Eliminating or overlooking critical tasks could create a false sense of security and lead to a series of maintenance failures. Extremely complex tasks are probably out of the realm of a preventive maintenance program and may require highly trained individuals who are not readily available in the plant department. Whenever possible, preventive maintenance tasks should be standardized for each type or class of equipment. This will simplify training and reduce preventive maintenance time.

Reference Documents

Most operating manuals or manufacturer's brochures will recommend some type of preventive maintenance schedule, which may be overly cautious and recommend an excessive oil or lubrication schedule. If manuals are not on hand, obtain them from the manufacturer or contact other institutions that have already implemented a preventive maintenance program and have the same type of equipment. One of the best sources of information is located within the plant department. The foreman or technicians who have been maintaining the equipment over a long period know the tasks they perform when the equipment fails and usually have a good idea what causes a failure or, better yet, what might prevent it.

General maintenance manuals published by such agencies as State Building Services, Government Services Administration, and Department of Navy Civil Engineering provide excellent references in determining preventive maintenance tasks on most items of equipment found on college and university campuses today.

Contents of PMIs

Preventive maintenance instructions should be standard to common components when possible and should be developed according to like items or groups of items. These instructions should emphasize preventive maintenance actions or checks and investigative actions such as checking for noise, vibrations, excessive weakness, overheating, and overall operation. Actual work might include alignments, adjustments, lubrication, cleanliness, and minor parts replacement such as belts.

To write the instructions it may be useful to observe the equipment in question to identify all required tasks. The tasks to be performed must be written on some type of checklist or card and contain as few words as possible. At the same time the instructions must ensure that each task description is specific, accurate, and easily understood. Keep in mind the educational and training level of the mechanics who will be reading, interpreting, and performing the inspections (Figures 3-6 and 3-7).

Determining PMI Performance Frequencies

One of the main goals of a preventive maintenance program is to reduce failures and major breakdowns. A major factor in determining the interval of preventive maintenance inspections is the frequency of breakdowns or defects and the consequences of such conditions. The seriousness of a breakdown is a function of the cost of operating or not operating the equipment (whether or not it is critical to instructional activities), and/or involves safety of personnel and property. Other factors that might be considered are the type of equipment and its usage. Some tasks may be based on operating hours rather than on a calendar.

Environmental conditions also play a part in determining inspection frequency. Such things as dust, water, and heat must be considered. Task frequencies will vary according to the age of the equipment and may be performed as often as daily but are usually scheduled on a weekly, monthly, quarterly, semiannual, or annual basis. Tasks should also be categorized into equipment that is operational or nonoperational, and may require a test run for proper performance evaluation. Tasks established for one piece of equipment can easily be modified for all other similar items in order to reduce writing time.

Estimating Manpower to Perform the PMIs

Another difficult task in the development of a preventive maintenance program is the establishment of total manpower/workhours required for the program. As stated earlier, the program at this stage is not manpower-limited. It is only after total workhours have been determined that the program should be modified in order to meet available resources. In the establishment of manpower requirements only estimate basic time—the time needed to perform the task at the equipment location. "What if the technician determines that maintenance tasks other than those specifically required for the inspection

Figure 3-6

Preventive Maintenance Procedure

Equipment No.________________ Equipment name:________________

Inspection Frequency (Monthly)

1. Change filters, 12 required, 24 by 24 by 8.
2. Check all bearings for noise or excessive temperature.
3. Check belt tension and condition.
4. Operation of traps, steam pressure, 5 lbs.
5. Check for leaks in unit around pipes and correct.
6. Clean area.

Inspection Frequency (Annually)

1. Shut down, open up for inspection and cleaning.
2. Remove guard on belt.
3. Take tension off belts.
4. Check bearing condition.
5. Replace belts and take up proper tension.
6. Check sheave alignment with yardstick, correct.
7. Replace guard.
8. If new belts are required, return in 24 hours to take up stretch.

Inspection Frequency (Semiannually)

1. Grease fan at two fittings.
2. Wipe up excess grease.
3. Remove plugs from electric motor, insert special fitting on fill.
4. With motor running force grease into bearing until grease appears at drain hole.
5. Remove special fitting and replace fill plug.
6. Run 20 minutes and replace drain plug.
7. Wipe up excess grease.

Repair Record

Date	Work Accomplished	Cost

Source: *Energy Managemenr Series,* Volume 7, Syska & Hennessy, Inc.

Figure 3-7

The University of Texas at Austin
Physical Plant Preventive Maintenance Instructions

PMI Number 05VEF1 Exhaust Fan Maintenance Instructions

	Weekly	Monthly	Quarterly	Semi-annual	Annual
Workhours		0.40	0.40		
Crew Size		1.00	1.00		

FREQ	CRFT	Task Descriptions
M	M	Check extent of corrosion and condition of paint, including motor
M	M	Tighten loose bolts, nuts, fasteners, and mounting support, including motor
M	M	Report/replace worn/damaged malfunctioning components, including motor
M	M	Repair/report causes of overheating, excessive vibration and unusual noises, including motor
M	M	Lubricate bearings/rollers/sleeve bearings, including motor
M	M	Clean screens and louvers, including motor
M	M	Tighten fan hub/sheave set screws (if applicable)
M	M	Check belt for wear, tension and alignment. Adjust as necessary or report if replacement is needed (if applicable)
M	M	Check sheave alignment. Report excessively worn sheaves, including motor (if applicable)
M	M	Check flexible connector (if applicable)
M	M	Clean the area
M	M	Complete maintenance record

should be performed?" Generally the technician will perform an additional task if it does not require a return to the shop for spare parts, etc. Remember that task length is only estimated. It will vary with the mechanic performing the task and the condition of the equipment at the time of inspection.

Now the plant director must evaluate the workhours available. Some authorities say the cost of the preventive maintenance workhours should equal 4 percent of the capital value or ensured value of the equipment being maintained. This sounds good on paper but to actually determine 4 percent of investment may prove difficult, if not impossible. There will likely be more workhours required than available. But remember, all items under consideration were placed in the intitial program with the realization that they might be removed later. It is now necessary to review the equipment included in the program and eliminate those items whose breakdowns result in the least cost both in time and operation to the institution. Next, the frequency of tasks should be reviewed and changed as appropriate to reduce workhours. The next item for review are the actual tasks. A limited preventive maintenance program is better than none at all. So, generally, it is better to change frequencies or tasks rather than drop the item from the program completely.

3.5 SCHEDULING PREVENTIVE MAINTENANCE

The key to implementing a preventive maintenance program is in its schedule, and the key to a good schedule is balance. Preventive maintenance tasks should not be grouped during any particular period but should present an even work flow over a given period of time.

Developing a Master Schedule

The master preventive maintenance schedule should span a full year and cover all tasks that fall within this period. Tasks should be distributed on a monthly basis keeping required workhours balanced from month to month. Generally, equipment downtime should be spread throughout the year, although there are items that can only be taken out of service when they are not needed (during Christmas vacation, spring break, etc.). Lengthy inspections on some equipment should be scheduled seasonally. Heating equipment should receive yearly checks in the summer, while air conditioning should receive major checks in the winter.

Another good method of master scheduling preventive maintenance is to establish the schedule on a fifty-two-week basis. Figure 3-8 is a form specifically designed for this type of master scheduling. Using this form the master schedule is developed as follows:

1. For a building, list the equipment number, description, and PMI number for each equipment item selected for the PM program.

Figure 3-8

Preventive Maintenance Master Schedule

BUILDING/FACILITY ____________

Equip No.	Description (Noun)	PMI No.	Week											EST. MH.
			1	2	3	4	5	6	→	49	50	51	52	
TOTAL WORKHOURS														

2. Refer to the PMI for each equipment item for the frequencies that each task is to be performed—weekly (W), monthly (M), quarterly (Q), semi-annually (SA), or annually (A). Indicate the week of the year that each frequency will be performed by placing a W, M, Q, SA, or A in the top half of the weekly square. In the bottom half of the square enter the estimated workhours required to perform the PM tasks at that frequency.

1	2	3	4	5	6	7	8	9	10	11	12	13
W	W	W	W M	W	W	W	W M	W	W	W	W M	W Q
.5	.5	.5	1.0	.5	.5	.5	1.0	.5	.5	.5	1.0	1.5

3. After the frequencies and workhours have been entered for all equipment items, total the workhours required annually for each equipment item and the workhours required weekly to perform the PM as scheduled.

4. If necessary, the weekly workhour requirements can be balanced between weeks by sliding the M, Q, SA, and A inspections one way or the other.

5. If the total workhour requirement is excessive in light of available workhours, it can be reduced by extending the frequencies where feasible.

This type of PM master scheduling is easily programmed for computer scheduling. The computer schedules by each week of the year as indicated on the master schedule.

Manpower availablity will fluctuate due to special events such as holidays, deer season, summer vacation periods, etc. Knowing the workhours associated with each preventive maintenance task, it is possible to balance the workhours to meet the availability of personnel. Equipment downtime or inactivity is kept to a minimum with the least disruption to the campus and its educational activities.

Developing Weekly Schedules

Monthly schedules are broken down into weekly schedules in much the same manner as the yearly schedule was broken down into a monthly schedule. However, there should be some spare or unscheduled time planned into the overall preventive maintenance schedule either the last day of each week or the last week of the month. There will always be missed schedules due to sickness, unprogrammed emergencies that may require the services of the preventive maintenance team, and/or equipment that cannot be taken out of service as originally scheduled.

The preventive maintenance program should be transferred from the master schedule (i.e., for one year) into some type of readily available weekly/monthly schedule. If the system is to be a manual system, it can be done using a marked calendar, a cardex system filed by the day of the month, Acme visual files that are color coded to identify a particular month, or any other suspense file that serves the same purpose. The Acme visual files appear to be the most economical and simplest to use. A quick scan of each drawer will indicate items that must be scheduled during the forthcoming month. If a permanent color code is not desirable, a color tab may also be used. The movable tab has the advantage of lending flexibility to scheduling since the month can easily be changed without redoing the whole card. For large preventive maintenance programs monthly scheduling boards may be useful. These boards indicate the preventive maintenance tasks scheduled for the month broken down by a particular craft or shop. Even more effective is a computerized preventive maintenance schedule that prints out the task to be scheduled on either a monthly or weekly basis.

A computer scheduled PM work order is shown in Figure 3-9. Based on the annual PM Master Schedule, the computer was programmed to schedule the Quarterly (Q) preventive maintenance instructions for the exhaust fan the ninth week of the year by shop Number 05. The bottom of the work order is used by the mechanic performing the work to enter applicable feedback data. This work order with all others scheduled for the ninth week of the year is sent to the responsible shop with a PMI Transmittal Report (Figure 3-10).

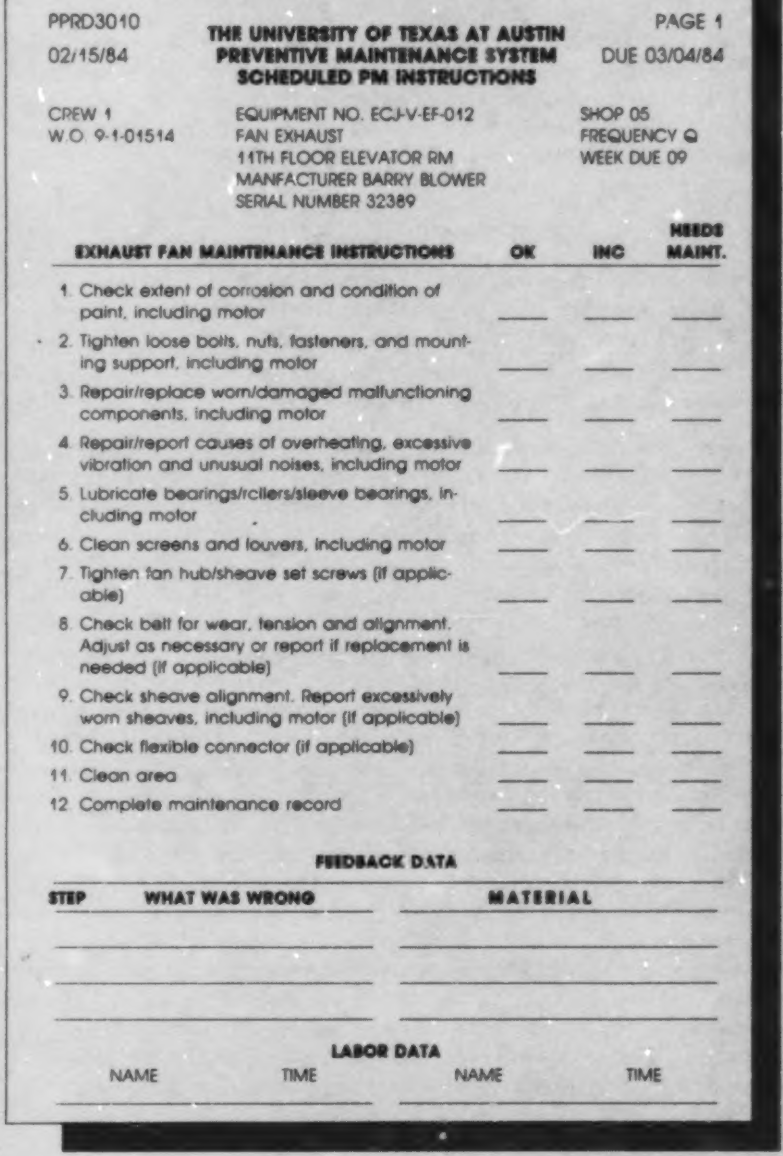
Scheduling Controls

In order to assure that the required tasks are performed there must be a strong commitment by management to the preventive maintenance program. Individuals assigned to preventive maintenance work must not be pulled from their schedule except in extreme emergencies. There will always be some preventive maintenance tasks each month that are not completed for one reason or another. The system developed must monitor these tasks to reschedule or cancel them. If similar problems continue month after month, the overall preventive maintenance program must be reduced in scope.

There are two basic methods of controlling the preventive maintenance schedule once it is established. One method is to fix the time when each inspection is to be performed—the annual inspection will always be performed in January, the semiannual inspection in July, and quarterly inspections in April and October. If one of these inspections is delayed, it will either be performed the following month or be canceled and the rest of the inspections will be performed during the same month. The other method of scheduling is to slide each inspection according to when the last inspection was performed. If the yearly inspection is delayed one month, all future inspections

Figure 3-9

Computer-Scheduled Preventive Maintenance Work Order



PPRD3010 PAGE 1
02/15/84 DUE 03/04/84

THE UNIVERSITY OF TEXAS AT AUSTIN
PREVENTIVE MAINTENANCE SYSTEM
SCHEDULED PM INSTRUCTIONS

CREW 1
W.O. 9-1-01514

EQUIPMENT NO. ECJ-V-EF-012
FAN EXHAUST
11TH FLOOR ELEVATOR RM
MANFACTURER BARRY BLOWER
SERIAL NUMBER 32389

SHOP 05
FREQUENCY Q
WEEK DUE 09

EXHAUST FAN MAINTENANCE INSTRUCTIONS	OK	INC	NEEDS MAINT.
1. Check extent of corrosion and condition of paint, including motor			
2. Tighten loose bolts, nuts, fasteners, and mounting support, including motor			
3. Repair/replace worn/damaged malfunctioning components, including motor			
4. Repair/report causes of overheating, excessive vibration and unusual noises, including motor			
5. Lubricate bearings/rollers/sleeve bearings, including motor			
6. Clean screens and louvers, including motor			
7. Tighten fan hub/sheave set screws (if applicable)			
8. Check belt for wear, tension and alignment. Adjust as necessary or report if replacement is needed (if applicable)			
9. Check sheave alignment. Report excessively worn sheaves, including motor (if applicable)			
10. Check flexible connector (if applicable)			
11. Clean area			
12. Complete maintenance record			

FEEDBACK DATA

STEP	WHAT WAS WRONG	MATERIAL

LABOR DATA

NAME	TIME	NAME	TIME

inspection is delayed one month, all future inspections move forward one month. This second method is the most practical but much harder to control. It causes a lot more administrative work if the preventive maintenance program is not computerized.

There must also be some follow-up method to ensure that the given tasks are performed as required. This follow-up should be performed by a preventive maintenance foreman or quality control inspector at regular intervals. Analysis of equipment breakdowns may also indicate a lack of proper preventive maintenance inspections.

3.6 PM MANAGEMENT CONTROLS

The controls described above concern scheduling and lower-level supervision (foremen and below). There should be additional controls and management tools that are used by the facilities director.

Performance and Effectiveness Indexes

A control that is important to management involves some type of cost accounting. The preventive maintenance program, like all maintenance activities, should have some interface with the general accounting system. This may be through a computerized transfer of cost figures or a manual entry of maintenance data into the accounting system. In order to provide a true picture of the preventive maintenance program, costs (labor and material) should be segregated from other maintenance activities such as corrective maintenance, repairs, and construction. PM costs should also be segregated by buildings and system type (HVAC systems, electrical systems, plumbing systems). There should be a relatively simple way of comparing estimated time to perform a given task versus the actual time. This comparison must be made of a number of repetitions of the task in order to average out idiosyncrasies caused by different mechanics performing the tasks, different conditions, etc. The plant director should receive cost information about the preventive maintenance program in terms of workhours, material, and total dollars.

The preventive maintenance program should be compared to the overall maintenance effort by determining percentage of preventive maintenance work orders performed versus total work orders, workhours spent on repair versus total workhours available, and direct costs of repairs versus total maintenance costs. The full effects of a preventive maintenance program in labor and dollar savings will not be realized for at least 12 to 18 months after implementation. Therefore, the initial implementation of a preventive maintenance program will require an increased expenditure in spare parts as a minimum and possible additional manpower if the original maintenance effort is to remain at the same level.

Figure 3-10

PMI Transmittal Report

PPRD3010
02/15/84

THE UNIVERSITY OF TEXAS AT AUSTIN
PREVENTIVE MAINTENANCE SYSTEM
TRANSMITTAL REPORT
SHOP 05 DUE 03/04/84

PAGE 2

Equipment No.	Equipment Description	PMI	F	Crew Size	Est. Work-hours
	Total estimated workhours for building EAH				0.70
ECJ-A-FR-001	FAN RETURN A/R	05AFR1	M	1	0.75
ECJ-A-FR-002	FAN RETURN A/R	05AFR1	M	1	0.75
ECJ-A-FS-001	FAN SUPPLY A/R	05AFS1	M	1	0.50
ECJ-A-FS-002	FAN SUPPLY A/R	05AFS1	M	1	0.50
ECJ-A-FS-003	FAN SUPPLY A/R	05AFS1	M	1	0.50
ECJ-V-EF-001	FAN EXHAUST	05VEF1	M	1	0.40
ECJ-V-EF-003	FAN EXHAUST	05VEF1	M	1	0.40
ECJ-V-EF-006	FAN EXHAUST	05VEF1	M	1	0.40
ECJ-V-EF-008	FAN EXHAUST	05VEF1	M	1	0.40
ECJ-V-EF-012	FAN EXHAUST	05VEF1	Q	1	0.40
ECJ-V-EF-013	EXHAUST FAN	05VEF1	Q	1	0.40
	Total PM work orders requiring		1 WKR	11	5.40

Equipment Failure Reports

As mentioned previously, preventive maintenance activities are recorded in a historical data file for each piece of equipment. This information, coupled with equipment failure rates, is another way to evaluate the effectiveness of a preventive maintenance program. Certain items should be flagged as critical and brought to the attention of the plant director. Critical items include equipment with 3 or more of the same type failures in any one year, the 10 items of equipment down the most number of times during a month, and the 10 items of equipment that cost the most to maintain. An equipment failure report identifying these items will change rapidly after the first two or three months of a preventive maintenance program and can be used as a major indicator of the success of the program itself.

3.7 ORGANIZATION AND STAFFING

As with any labor intensive program, the individuals selected to schedule, monitor, and perform the tasks are vital to the success of the preventive maintenance program. The idea of a preventive maintenance program will probably be a new concept to many members of the plant department. Their understanding and acceptance of the program is paramount to its success.

Organization

The type of organization formed to implement a preventive maintenance program will vary according to the size of the institution, the classification of employees within the plant department, and the desires of the director. During the task-selection procedure, attention should have been given to the types of employees required to perform the tasks (electrician, plumber, general maintenance repairman). Preventive maintenance work may be performed by individuals from various shops, by a preventive maintenance shop itself, or by a preventive maintenance team under the management of a preventive maintenance foreman. The means chosen is usually determined by the size of the facility and/or the classification of the maintenance workers themselves. If a union exists within the maintenance department, it may also play a role in deciding what types of employees perform the preventive maintenance tasks.

The most efficient classification of worker to perform a preventive maintenance task is that of a general maintenance mechanic—one who can check an electric motor, a pump, and an air-handling unit all at the same time—rather than requiring three separate journeymen to check each major piece of equipment. Within the scheduling office the same individual should schedule all preventive maintenance tasks. This ensures consistency, and the scheduler develops a thorough knowledge of the overall program.

Staffing

There is no question that the implementation of a preventive maintenance program will require additional personnel to perform the administrative tasks. Usually, the preventive maintenance scheduler can also maintain and keep current the equipment history records, as well as adjusting the schedules to reflect inspections. In large institutions adjusting schedules may require the services of a clerk *and* a preventive maintenance scheduler, especially if the scheduler is responsible for scheduling other maintenance activities. In the long run a preventive maintenance program will reduce the overall maintenance man-hours required, so additional staffing on a temporary basis is not recommended. It is more practical to reduce other activities during the implementation phase of the preventive maintenance program.

Personnel Qualifications and Skills

A successful program rests on the selection of individuals to perform the actual preventive maintenance tasks. These mechanics must have technical skills including knowledge of the equipment and its operation, troubleshooting abilities, and familiarity with the plant's overall design and function. They must have personality traits that lend themselves to performing repetitive tasks and completing paperwork. Over time, complacency can do more to undermine the overall preventive maintenance program than any other single factor. It is not uncommon for some preventive maintenance workers to develop the attitude that they "checked a certain piece of equipment last month, so why bother to look at it again this month." Other individuals performing preventive maintenance work may take great pride in their work and feel personally responsible for the equipment they inspect.

Studies have been conducted in order to determine whether individuals should perform only preventive maintenance tasks or a mixture of regular maintenance activities and preventive maintenance work. The advantage of the latter, of course, is that an increased variety of jobs tends to alleviate boredom. When this type of scheduling is used, individuals tend to perform the preventive maintenance tasks in a more professional manner in order to preclude failure and a subsequent repair job. On the other hand, if workers perform only preventive maintenance tasks, they get to know the equipment much better, recognize changes from inspection to inspection, and in some instances, can even identify a change in sound from one inspection to another.

3.8 IMPLEMENTATION OF THE PM PROGRAM

After completing the planning phase in a satisfactory manner, the implementation phase of the preventive maintenance program should proceed smoothly. There is really nothing more to do than perform the inspections required. Some details need to be finalized at the beginning of the implementation phase.

Policies and Procedures

As stated before, the preventive maintenance program may be new to most plant personnel. So everyone can fully understand the importance and significance of the program, the director should publish an operating policy concerning the preventive maintenance program. Along with the policy, written procedures that direct the actual operation of the program should be provided. These procedures should describe the purpose of the program, responsibilities of each section of the department, the actions required by these sections, procedures to be followed by the mechanics involved in performing the tasks, details concerning issuance of work orders, time and material reports, maintenance of the equipment historical cards, etc.

The procedures should present an outline of the organization established to implement the preventive maintenance program and the proper channels to follow when problems arise. These procedures should be distributed to the individuals directly involved in the PM program and to all supervisors within the department. This way they will better understand the importance and workings of the preventive maintenance program (Figure 3-11). A sample administrative procedure for a computerized PM program is found in Appendix 3-B.

Training Personnel

Although the individuals assigned to perform preventive maintenance tasks were selected for that purpose, there will be some additional training required, especially in the areas of proper documentation and work accountability. If the mechanics are unfamiliar with the particular piece of equipment, they will need time to review the operating manuals and perform the initial preventive maintenance tasks under supervision. Once the preventive maintenance program is in full operation, replacement personnel may be trained by accompanying an experienced mechanic who is selected for his or her communications skills and teaching ability.

Special Tools and Supplies

The preventive maintenance task cards should identify any special tools or equipment needed to perform preventive maintenance inspections. It may even be necessary to purchase special tools to perform certain preventive maintenance tasks. After the mechanics become familiar with the equipment and tasks, they will automatically know what tools are needed (Figure 3-12).

As stated earlier, stock levels for certain spare parts may need to be increased as a result of the preventive maintenance program. Items such as belts, gaskets, and filters will probably be used quickly as a result of the program. Although use of additional material will initially increase the cost of the preventive maintenance program, the savings as a result of reduced downtime and failures will far exceed the additional cost of material.

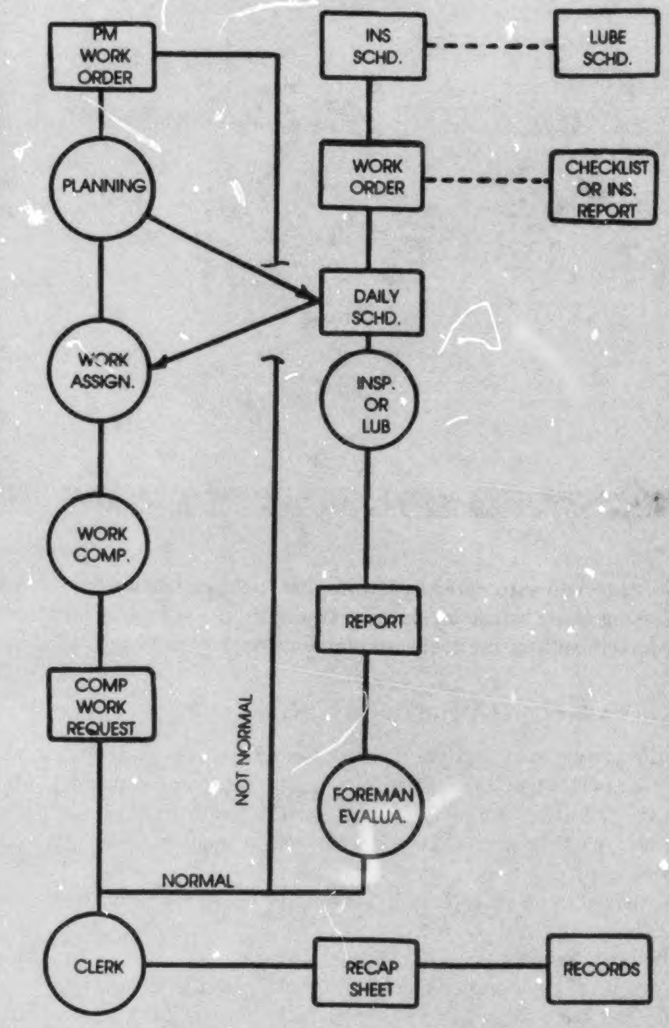
Implementation

A preventive maintenance program should be implemented in phases with no more than 40 percent of the program implemented in the initial phase. Phases may be determined by area, building, relative importance of equipment, or ease of tasks. Work orders for preventive maintenance should include equipment identification, location, and type of preventive maintenance check—weekly, monthly, quarterly, semiannual, annual.

Information provided by the mechanic performing the task should include man-hours required, material used, individual identification, and any major problems discovered but not corrected. The equipment historical files must then be updated indicating the preventive maintenance tasks performed, any

Figure 3-11

Typical Flow System


PM WORK ORDER
PLANNING
WORK ASSIGN.
WORK COMP.
COMP WORK REQUEST
CLERK
INS SCHD.
LUBE SCHD.
WORK ORDER
CHECKLIST OR INS. REPORT
DAILY SCHD.
INSP. OR LUB
REPORT
FOREMAN EVALUA.
NOT NORMAL
NORMAL
RECAP SHEET
RECORDS

Source: *Energy Management Series*, Volume 7, Syska & Hennessy, Inc.

Figure 3-12

Inspection Tools

Tools	Inspection Uses
Stethoscope	Valve, Gear, Bearing Defects
X-Ray Equipment	Material Flaws
Dye Penetrant	Material Flaws
Ultraviolet Light	Material Flaws
Magnetic Particles	Material Flaws
Ultrasonic Testers	Subsurface Defects
Vibration Meters	Rotating Machine Defects
Recording Ammeters	Electric Equipment Performance
Recording Voltmeters	Electric Equipment Performance
Recording Temp. Gages	Bearings, Hydraulic,
Recording Press. Gages	Pneumatic Systems
Surface Pyrometers	Temperatures
Megger	Electric Motor Insulation
Infrared Sources	Temperature Gradients
Nuclear Sources	Moisture Detection

Source: *Energy Mangement Series,* Volume 7. Syska & Hennessy, Inc.

excessive materials used, and any work performed or needed other than preventive maintenance. Accident prevention and proper safety habits must be emphasized during the implementation phase of the program.

Common Problems and How to Avoid Them

During the early stages of a preventive maintenance program, the maintenance repair backlog will greatly increase. This happens because equipment is being looked at on a scheduled basis and major defects identified. The backlog will return to normal after the preventive maintenance program has been operating a number of months.

Problems can develop rapidly if the employees assigned to the program do not fully understand the basic philosophy of preventive maintenance. It cannot be repeated enough—the program's success depends on the attitudes of the workers. Many programs have been started but not given a high enough priority. They were soon dropped for lack of effectiveness. Other programs run into difficulties because management did not develop the proper controls or personnel were not properly trained. Improvements in equipment operation will be noticeable at about 6 months, while overall costs savings will not be identified for almost 12 months.

3.9 CORRECTIVE MAINTENANCE

Corrective maintenance is the study of historical records (repetitive failures) to determine the actions needed to prevent reoccurrence and then taking proper corrective actions. Corrective maintenance results from a good preventive maintenance program.

A preventive maintenance program needs regular review and updating. Some of the initial frequencies selected for performing preventive maintenance tasks will have to be changed (either increased or decreased). In addition, the time required to perform the tasks will also change, especially as mechanics become more proficient.

Maintenance Analysis

As a result of the preventive maintenance program and the documentation associated with it, failures and breakdowns will be identified easily. A maintenance analysis program will identify the cause of these failures (faulty design, faulty manufacture, incorrect operation, lack of proper preventive maintenance, etc.). Maintenance analysis can also identify mean times between failures of components and overall expected life of a piece of equipment (Figure 3-13).

Corrective Action

After maintenance analysis is complete, it may be necessary to revise preventive maintenance tasks and/or frequencies and establish a schedule for changing equipment component parts based on estimates of the mean time between failures. It may even be necessary to replace the item itself or perform major modifications in order to improve operating characteristics. An analysis of the preventive maintenance program may indicate that improved supervision is all that is necessary to improve the program.

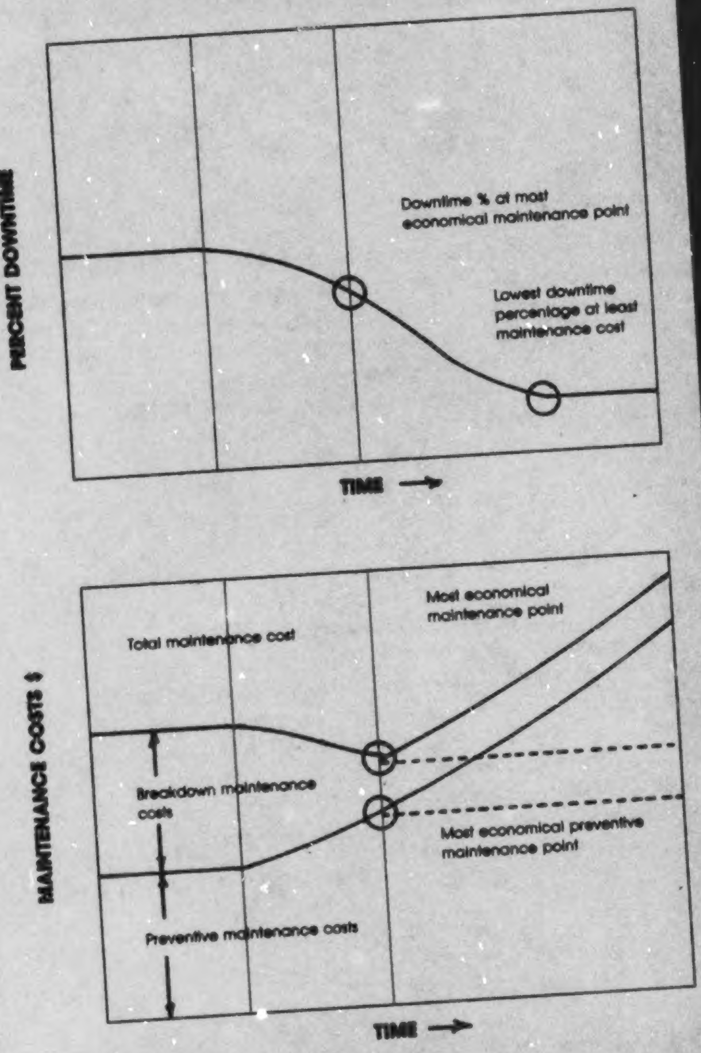
A financial analysis of the program should also be made on a periodic basis in order to determine not only the cost of the program but its effect on overall maintenance costs. Generally, the distribution of total maintenance costs with a formal preventive maintenance program should be as indicated:

	Labor percentage	Material percentage
PM	15	5
Planned	75	75
Repairs	10	20

As used above, preventive maintenance indicates work done in the preventive maintenance program itself. Planned maintenance is work identified through the PM program or by other means and performed on a scheduled

Figure 3-13

The Economics of Preventive Maintenance
Maintenance Analysis Curves



basis. Repairs identifies work done when equipment actually breaks down and must be fixed immediately.

3.10 Conclusion

Although guidelines have already been provided, for many the question remains. How many workhours and how much material should I commit to a preventive maintenance program? There should be no doubt that a well-run preventive maintenance program will result in significant savings in both workhours and material over the long term. But—equally important—an effective PM program will improve the overall operation of the plant equipment, reduce breakdowns and interruptions of service to the educational facilities, enhance the professionalism of the plant department, and greatly ease the strain on its director.

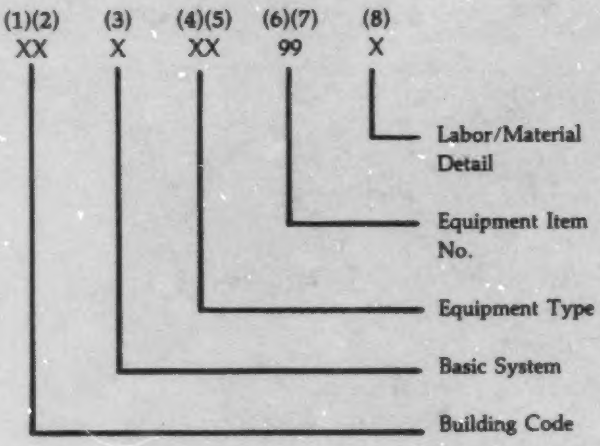
Appendix 3-A

"Dual-control" Numbering System

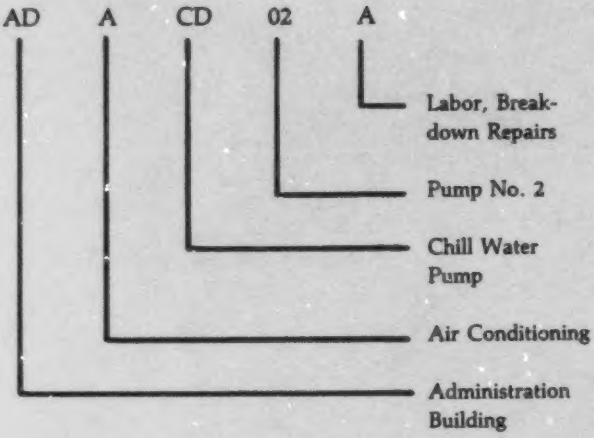
ADVANTAGES

- One Number Serves Two Purposes
    - ☐ Equipment Identification
    - ☐ Cost Accounting
- Segregates Costs (Labor & Material) by Maintenance Category
    - ☐ PM
    - ☐ Planned Maintenance
    - ☐ Corrective Maintenance
    - ☐ Repairs
- Segregates Costs (Labor & Material) by Maintenance Category
    - ☐ Building
    - ☐ Basic System
    - ☐ Sub-system
    - ☐ Equipment Item
- Very Adaptable to ADP
- Simple System for Personnel to Use

FORMAT


(1)(2)
XX
(3)
X
(4)(5)
XX
(6)(7)
99
(8)
X
Labor/Material Detail
Equipment Item No.
Equipment Type
Basic System
Building Code

EXAMPLE


AD
A
CD
02
A
Labor, Breakdown Repairs
Pump No. 2
Chill Water Pump
Air Conditioning
Administration Building

TYPICAL DETAILS FOR DIGIT #8

A	Labor, Breakdown Repairs
B	Labor, Planned Maintenance
C	Labor, Preventive Maintenance
D	Parts & Materials, Planned Maintenance
E	Parts & Materials, Preventive Maintenance

TYPICAL DETAILS FOR DIGITS #4 & #5—EQUIPMENT TYPE

AH	Air Handlers
EM	Electric Motors
FN	Fans
HG	Hot Water Generators
CP	Centrifugal Pumps

TYPICAL DETAILS FOR DIGIT #3—BASIC SYSTEM

A	Air Conditioning
E	Electrical (Power)
H	Heating
L	Electrical (Lighting)
V	Ventilation
S	Sewage
W	Water

EXAMPLE OF PHYSICAL SEGREGATION OF EQUIPMENT

AD-0-00-00-0	**Administration Building**
AD-A-00-00-0	**Air Conditioning System**
AD-A-AH-01-0	Air Handler #1
AD-A-EM-01-0	Electric Motor #1
AD-A-AH-02-0	Air Handler #2
AD-A-EM-02-0	Electric Motor #2
AD-A-CP-01-0	Chilled Water Pump #1
AD-A-EM-03-0	Electric Motor #3
AD-A-PP-01-0	Piping/valves
AD-H-00-00-0	**Heating System**
AD-H-BR-01-0	Boiler #1
AD-H-BR-01-0	Boiler #2
AD-H-CP-02-0	Condensate Pump #2
AD-H-EM-04-0	Electric Motor #4
AD-H-PP-01-0	Piping/Valves
AD-E-00-00-0	**Electrical Power**
AD-E-SG-01-0	Switchgear #1
AD-E-TF-01-0	Transformer #1
AD-E-PN-01-0	Power Panel #1
AD-E-WN-01-0	Wiring

Appendix 3-B

Administrative Procedures

SUBJECT: Preventive Maintenance Program

I. Purpose

To establish a procedure for scheduling, accomplishing, and controlling the Preventive Maintenance (PM) Program, and to assign the specific responsibilities of each action organization.

II. Action Organizations

Technical Services and Construction and Maintenance

III. General

Preventive maintenance is the utilization of planned services, inspections, adjustments, and replacements designed to ensure maximum utilization of equipment at minimum cost. The preventive maintenance program consists of the development, implementation, and evaluation of Preventive Maintenance Instructions (PMIs), and procedures and evaluations of repetitive problems of all maintenance performed. Specifically, PM includes cleaning, adjustments, lubrication, minor repairs, and parts replacement that are performed on scheduled frequencies in accordance with written Preventive Maintenance Instructions. Major repair jobs identified by the PM process are performed as planned maintenance projects through the normal work order system.

IV. Definitions

A. *Departmental Services* Those services rendered by the Physical Plant as requested by departments or other comparable agencies within the university. Such services are normally for the exclusive benefit of the requesting department. Included in departmental services are fabrication or installation of departmental equipment; operation, maintenance, and repair of departmental equipment; supply of materials for departmental use; rendering of moving and hauling services; extension of utilities to accommodate departmental equipment, etc. Departmental services are paid for by the department making the request.

B. *Institutional Services* Those services performed by the Physical Plant for which funds have been appropriated through the normal budget process for operating and maintaining the general institutional facilities, buildings, and grounds. Such services include lighting, heating and air conditioning, utilities, care of restroom facilities, cleaning of buildings, trash disposal, care of grounds, and maintenance and repair of buildings, etc. Such services are rendered without charge to any department.

C. *Preventive Maintenance Instructions (PMIs)* Detailed task instructions delineating the specific work to be accomplished on a recurring basis of Weekly (W), Monthly (M), Quarterly (Q), Semiannually (S), or Annually (A) to ensure maximum utilization of the equipment/facilities for a minimum cost.

D. *Planned Maintenance Work Order (PWO)* The scheduled replacement of major components or repairs that have been identified by the PM program or other sources as necessary to prevent a failure of the equipment in the near future.

E. *Corrective Maintenance Work Order (CWO)* The analysis of repetitive failures and the determination of corrective action, such as the replacement of equipment or major components.

F. *Cyclic Maintenance (CM)* Planned Maintenance that has a frequency greater than one year.

G. *Emergency Work Order (EWO)* Unplanned repairs to restore a failed system to its designed function.

V. **Responsibilities**

A. Department of Technical Services (TS) is reponsible for weekly scheduling, analyzing, updating, and managing the Preventive Maintenance Program.

B. Department of Construction and Maintenance (C & M) is responsible for daily scheduling, completion, analysis, and cost accounting of the Preventive Maintenance Program.

C. Academic and Support/Service Departments approve/disapprove all Departmental Maintenance Programs recommended by Physical Plant and include appropriate fund citation.

VI. Procedures

A. *Scheduling of PM Programs*

1. Maintenance Engineering Branch of TS will provide the data entry of the master schedule developed by Maintenance Engineering and provide input for any changes that may develop as the program progresses—frequency change, addition/deletion of equipment, etc.
2. Planning and Scheduling (P & S) section of TS will *reserve* the workhours by shop as scheduled by the automated program in each weekly schedule. P & S will forward 2 copies of the weekly Transmittal Report and the copies of the PMIs to the appropriate Construction and Maintenance shop scheduler one week prior to scheduled work accomplishment. Central Scheduling will coordinate with the appropriate departments any equipment shutdown that may be required to accomplish the scheduled PM.
3. C & M shop schedulers will include the PM work in the daily schedule to ensure that the PM is accomplished each week. One copy of the Transmittal Report will be forwarded to the appropriate shop supervisor with the PMIs for each piece of equipment.
4. C & M shop supervisors will assign the PM work to the craftsmen in accordance with the daily schedule to accomplish the maintenance tasks as outlined on each PMI.

B. *Completion of Scheduled Work*

1. C & M shop supervisors will issue the appropriate PMI to the craftsmen when assigning the scheduled maintenance.

2. The craftsmen will complete the PMI Feedback Data for each piece of equipment *at* the job site as the maintenance is performed. The craftsmen *must* indicate by checking one of the three status blocks as to whether: (1) maintenance is complete; (2) maintenance is incomplete; (3) equipment needs maintenance. If status (2) or (3) is checked, an explanation is required in comments section. The craftsman will always enter his or her name and time spent performing the work on each PMI.

C. *Cost Accounting*

1. The computer programs will generate a preventive maintenance work order for each equipment number scheduled.
2. Each craftsman will complete the PMI Labor Data by listing his or her name and time spent in performing scheduled maintenance on each PMI. Bench stock items (oil, grease, nuts, bolts, etc.) will not be charged on each PMI. Materials (belts, bearings, couplings, etc.) will be charged against work order number when issued by Central Stores issue clerk.
3. C & M shop supervisors will review each PMI for completeness of performance and time charges, then forward to C & M clerical staff for data entry.
4. C & M clerical staff will enter workhours and craftsman's social security number for each PMI completed by work order.

D. *Program Analysis and Generation of Planned Maintenance Projects*

1. The C & M shop supervisor will review each completed PMI to determine if additional maintenance is required. The supervisor will initiate a work request with Planning and Scheduling if additional maintenance is required.
2. P & S will process an individual work order requested by the work center supervisor for cost purposes and scheduling. They will also forward copies of each PWO and EWO to maintenance engineering for further study and evaluation.

3. Maintenance Engineering will review *all* planned maintenance work orders and emergency work orders and coordinate with C & M superintendents on possible changes needed to prevent excessive PWOs or EWOs on any equipment. Change of frequency and tasks will be coordinated between C & M superintendents, shop supervisors, and Technical Services engineers prior to any corrective maintenance work order being procesed or any changes to the scheduled PM. The Maintenance Engineer will also initiate work requests to P & S for Corrective Maintenance Projects.
4. Special, exception reports will be generated by the computer program. Examples of these reports are:
    - a. PMIs scheduled, not completed (monthly)
    - b. Ten items of equipment with highest maintenance dollar (monthly, semiannually, and annually)
    - c. Facility Subsystem with greatest maintenance expenditure (annually)

Additional reports will be generated as program progresses and in accordance with management needs.

E. *Updating Equipment Inventory and Schedule Changes*

1. P & S will initiate an Equipment Data Sheet each time a piece of equipment is replaced by shop work order or contract. This Equipment Data Sheet will be forwarded from P & S to the responsible shop supervisor for completion. The completed Equipment Data Sheets will be forwarded to Architecture & Engineering Services for action by the Maintenance Engineer. The same procedure shall be followed for all additional equipment installed and for all equipment removed from service.
2. Maintenance Engineering will review forms for completeness and assign an equipment number to additional inventory. Additional PMIs, if needed, will be developed and coordinated with C & M personnel.
3. Clerical staff in A & E Services will provide the data entry to the PM Data Files for additions or deletions of equipment.

4. Changes to the schedule for added/deleted equipment will be coordinated by Maintenance Engineering and C & M to ensure balanced manpower requirements.
5. Clerical staff in A & E Services will provide data entry of new PMIs and schedule changes.

VIII. Approvals

Director of Physical Plant	Director, Plant Management and General Services

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CHAPTER 4

Capital Renewal and Replacement/Deferred Maintenance

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University of Missouri/Central Administration

4.1 THE BIRTH OF CAPITAL RENEWAL AND REPLACEMENT

One of the basic principles of corporate existence is that of depreciating capital assets. Variations on the basic process range from straight-line depreciation to the varied and exotic depletion allowances provided mining and oil exploration companies. Whatever its form, the concept of depreciation is an attempt to acknowledge, in an accounting sense, the simple fact that sooner or later everything wears out or runs out.

That simple statement is integral to the following discussion. Man's search for immortality has failed miserably. His efforts to extend his influence beyond his lifetime are usually in the form of art or literature, and even those fade and crumble. The creations of man have life expectancies ranging from nanoseconds to centuries, but eventually they all die.

Looking at the standard possessions of life—homes, cars, appliances—reveals life expectancies of months or years. For the most part, these things begin to wear out the moment they are made.

Even the eight miles on the odometer of a new automobile represent fractional wear—yet the beginning of many microscopic deteriorations that will eventually become visible and ultimately lead to the end of the car's usefulness. The profitmaking sector of American enterprise is careful to document this deterioration in its accounting procedures. An asset (let's stay with the example of the car) is acquired for $10,000. The various components have useful lives that can be predicted with some accuracy. Assume that the useful life of the car is 10 years. At the end of that time a new car will be needed and money for its purchase required. How nice it would be to drive a new car for nine years and not worry about its replacement that whole time.

What's more, how nice to continue to value that car at its original price, even though it's wearing out.

Businesses recognize the foolishness of that approach. Owners are concerned that each year accurately reflect the profitability of the operations. The financial statements must realistically state the value of the business's assets to reflect that portion of the asset's life that was used. Each year that new car will be reduced in book value by $1,000, because the total $10,000 cost divided over 10 years equals $1,000 per year.

In order to break even each year, the activities of the business must generate $1,000 in surplus to cover that allowance called depreciation. So legitimate is this concept that the United States Internal Revenue Service recognizes that the $1,000 as an expense to the business—as if the business had written a check in that amount.

The more expenses business can document, the less their profit and, therefore, the less tax they must pay. Since paying less taxes generates additional cash for their owners, it is a practice carefully pursued. Recognizing depreciation enables businesses to generate cash without investing any real dollars.

The basic differences between profitmaking and nonprofit organizations is not that the former generate a profit and the latter do not. In fact, quite the opposite is often true. The difference is that the two do or do not, respectively, pay taxes on that profit.

One of the primary goals of business is to run a profitable operation. This is true of profitmaking and nonprofit enterprises. College and university presidents will confirm this if asked how long their tenures would be if operations were in the red each year—showing a loss rather than a profit. Most would acknowledge that this is unacceptable performance. Pressure exists to ignore depreciation in the nonprofit sector for exactly the opposite reasons that apply to the profitmaking sector. In nonprofit organizations reduced expenditures in one area support higher levels of spending in other areas without changing the bottom line. Programs that are not cost-effective can continue and the budget remains balanced by not recognizing the depreciation expense.

The concept of capital renewal and replacement recognizes two forms of expenditure necessary to accommodate the depreciation process—renewal costs to restore deteriorated assets, and replacement costs incurred when renewal is not feasible or justified. Capital renewal and replacement (CRR) is a process in which responsible facilities administrators engage and for which they plan.

Returning to the basic axiom—everything wears out—it becomes apparent that a key function in effective plant management is controlled deterioration of the capital assets. Fundamental to this is the fact that needed maintenance does not go away—it can only be postponed. Exercising proper maintenance management minimizes the cost of this deterioration while maximizing the utility of the deteriorating asset. Much can be done to delay the inevitable deterioration. Renewal and repair are essential elements of maintenance management. It is the failure to perform needed repair, maintenance, and renewal that we classify as deferred maintenance.

4.2 DEFERRED MAINTENANCE

The unchecked deterioration of capital assets with no reserve fund for renewal or replacement has created a condition at many institutions aptly termed capital anemia. When a person is anemic, the blood is deficient in red blood cells, in hemoglobin, or in total volume. Anemia has a variety of symptoms that are analogous to the concerns of plant admininstrators. At the early stages, anemia is difficult to detect. Its effect on the host is minor, and it requires microscopic investigation by a trained observer to confirm its presence. In subsequent stages, anemia becomes apparent to the host as vitality leaves and productivity and performance suffer. When anemia becomes apparent to the untrained eye, its damage is severe and major attention is needed to reverse its trend. In the absence of proper attention, the host will eventually die.

So is the nature of deferred maintenance. At its earliest stages, the most astute observers may overlook its presence. Detailed inspection is needed to detect the presence of deferred maintenance and enable an early cure. In any event, its impact in this early stage is minor at most. Soon, however, the vitality of the plant asset is weakened as increased failures and decreased efficiencies take their toll. By the time casual observers begin to detect and identify the presence of deferred maintenance, the effort needed to correct the problem and reverse the trend is so great as to threaten the existence of the host—the institution.

Defining Deferred Maintenance

Deferred maintenance has become a buzzword in academic circles. Efforts originally initiated by the Association of Physical Plant Administrators of Universities and Colleges made administrative colleagues aware of the reality, extent, and implications of deferred maintenance on our nation's campuses. A basic problem remains. At the core of the problem of deferred maintenance is its definition. The most comprehensive definitions imply that deferral has been caused by negligence rather than conscious planning.

Attempts to precisely define deferred maintenance have often overshadowed the more important task of controlling deterioration. There is basic agreement that maintenance represents the allocation of resources necessary to keep facilities as close to their original condition as possible until their maximum useful life is attained and replacement is required. Thus, a controlled maintenance program is represented by the resources expended in a scheduled manner to prevent excessive deterioration. The difficulty of reaching a workable definition of deferred maintenance is illustrated by both the tedious process and the result of the APPA Deferred Maintenance Committee.

> Deferred Maintenance is the labor and materials expended in periodic restoration of facilities that are deteriorating on time cycles of more than one year. The concept of deferred maintenance derives primarily from the budgeting practices of institutions wherein maintenance funds are allocated on a regular basis, but without cash reserves established for the restoration of facilities with maintenance life cycles of greater than one budget cycle (usually one year). For example, a roof that has a useful life of 25 years may be considered to have accumulated a partial deferred maintenance expense of fifteen twenty-fifths of its restoration cost. When the roof is 25 years old (and at the end of its useful life) the entire replacement cost must be available to restore the roof to a new useful life. Without a replacement reserve the funds generally are drawn from operating capital.

This quantitative definition contrasts to those that try to reflect a more descriptive analysis of the process involved. In 1977, the Nebraska state legislature adopted a definition of deferred maintenance in its Legislative Bill 309:

> Deferred maintenance shall mean any measures taken to correct structural or mechanical defects that would endanger the integrity of a building or its components or allow unwanted penetration of the building by outdoor elements, or measures taken to correct a waste of energy, including minor repairs, alteration and maintenance painting, cost of materials, hiring of building maintenance personnel, and other necessary expenses for the maintenance of roofs, exterior walls, retaining walls, foundations, flooring, ceilings, partitions, doors, building hardware, windows, plaster, structural ironwork, screens, plumbing, heating and air conditioning equipment, or electrical systems, but excluding decorative finish or furnishing, building additions, or installation of additional summer-winter air conditioning.

This definition tries to close the loopholes whereby an enterprising administrator might use this new funding to air condition an office or add a new wing to a building. It also illustrates a second view of deferred maintenance. Deferred maintenance is an action taken at a time that accounts for both normal deterioration of facilities and failures due to neglect or abuse.

It has been said that the technical aspects of maintenance programs represent 90 percent of the problem. The remaining 10 percent is the presentation of material in a manner convincing enough to obtain the highest possible funding priority. To that end, the definition used should be one that communicates the local problem to the appropriate authorities. There is no need to embellish the problem since a realistic presentation, clearly defined, and using an accurate system of measurement will be convincing enough.

The definition adopted must be acceptable to the funding body of the institution. It should be drafted with opinions from representative elements of the campus community. It must be accepted formally by the governing board or legislature and have the full support of the highest level of administration. The timing of the definition is also critical. It must be established before any meaningful efforts begin to quantify deferred maintenance. Otherwise, partial estimates might create panic. In this environment an honest definition would not be accepted and administrators would tend to invalidate the most carefully prepared analysis.

The definition must be established within the context of other physical plant problems and procedures. Specific reference should be made to a programmed maintenance function that exists but has been debilitated due to lack of funding. The built-in deficiencies of new construction requiring major capital investment must be mentioned. Buildings that predate legislation regarding handicap access and other code compliance may carry a cost potential that should be identified and allowed for in the definition.

Without being vague, the definition should accommodate unforeseen concerns that may arise as the process unfolds. Examples should be illustrative rather than inclusive. The definition used by the Nebraska legislature is an example of trying to cope with specific problems rather than general principles.

Why defer maintenance? The best answer to that question is a true story. Some years ago an APPA member was to speak about deferred maintenance at a meeting that included college and university chief executives. Prior to his presentation the speaker talked with the president of a large university. "I understand you're going to speak on deferred maintenance," the president said. "I'm really looking forward to that session. We're really pressed financially and looking wherever we can for ways to avoid spending money. I hope you can show us some good ways to defer maintenance."

The only difference between the president's statement and the philosophy that undergirds most of our institutions is that he stated it more directly than most. Maintenance dollars are not romantic. Their results are intangible, and the results of dollars not spent may go undetected for several years. Facilities administrators have, historically, been reluctant to react as strongly as a professor does whose program is cut.

Two major factors have aggravated the problem. The building boom of the 1950s and 1960s dramatically increased gross building square footage while institutions failed to provide the dollars necessary for increased maintenance costs. Those buildings are coming of age and require increased levels of time and money due to deterioration. Through it all, utility costs have risen disproportionately to other operating costs. For years, facilities budgets received the same incremental increases as other program areas, even though the major expenditure base was increasing at a rate five or six times in excess of the cost-of-living index. The function that sustained the brunt of this attack was preventive maintenance and programmed replacement or repair. Six-year carpet replacement frequencies were stretched to 10. Painting was done every five years instead of three. Tuckpointing waited until it could wait no more. Many harmless elements combined to form a time bomb of fiscal disaster.

The Magnitude of Deferred Maintenance

Surveys and other statistical studies attempting to estimate nation-wide deferred maintenance have yielded estimates ranging as high as $45 billion. Although not unique, buildings in the Los Angeles Unified School District have been closed because accrued repairs rendered them uninhabitable, and there are no dollars available to correct the problems. In terms of institutional solvency, unspent capital renewal and replacement dollars are keeping over 50 percent of colleges and universities in the United States from operating in the red each year.[1]

Even more difficult to measure is the crippling effect of deferred maintenance on efforts to organize and administer the physical plant department. When many plant administrators are making a concerted effort to stop fighting fires and gain control, deferred maintenance is there to undermine even the most comprehensive effort. Workers are demoralized as they struggle to fulfill repair requests. The plant department's image suffers as budget administration becomes more difficult and unanticipated breakdowns of major systems occur. The institution's image suffers as once-beautiful classroom and office buildings, and residence halls, slip into disrepair.

The influence of deferred maintenance on the operating budget of the institution cannot be ignored. Even though fewer dollars are spent on maintenance, costs for ongoing operations increase. Increased failure frequencies are expensive, as is the downtime that accompanies them. Energy-inefficient systems consume utility dollars needlessly. Even cleaning and security is more expensive for deteriorating facilities than for properly maintained ones. Inefficiently designed or improperly used space leads to new construction or rental.

A formula for forecasting the *future* impact of current deferred maintenance was devised by J. Peyton Fuller of Duke University. His formula is sensitive to a variety of forces including inflation, ongoing deterioration, and reduced efficiency.[2] Formulas are not needed to document the many and varied deficiencies that exist when maintenance is deferred and remains so. The productivity of the institution suffers as space efficiency is lost through neglect. Closing rooms, wings, or whole buildings is not uncommon and directly affects the institution's ability to fulfill its academic mission. Disrepair detracts from the learning environment with wide-ranging results including enrollment losses. Outstanding faculty are harder to attract to a deteriorating campus, and the quality of the academic program declines.

4.3 MANAGING FOR CAPITAL RENEWAL AND REPLACEMENT

When a subway train pulls into a station, it comes to a stop, opens its doors, and waits for the people to board before proceeding. The reason it does this, rather than merely opening its doors as it goes by at 50 miles an hour, is apparent.

Unfortunately, college and university physical plants are not as easily controlled. Managing for capital renewal and replacement must be accomplished as the train goes by, sometimes with the doors closed. Where no program has existed in the past, a plan must be instituted for future needs, and pre-existing conditions must be identified and addressed. A capital renewal and replacement program addresses needs in three time frames—the past, present, and future.

Past to Present: Measuring Existing Conditions

Every year stores, warehouses, factories, and supply houses stop their primary activity to take an inventory. This inventory determines the current status of stock so managers (1) know what happened since the last inventory, and (2) can plan for the future. Human relations experts encourage us to take personal inventories to help us plan our lives. The basic principle of any inventory is to determine where we have been and where we are now, so we can get where we want to go.

Facilities administrators know their campuses in terms of building type, square footage, general condition, type and age of major components, etc. Yet the detailed, current information needed to make valid decisions regarding budget, staffing, and space planning may not exist in any one place and in a comprehensive form. Since maintenance is less than an exact science to begin with, the absence of this information renders the decisions made and actions taken even more prone to error and deviation.

The only source of this information is the facilities themselves. A comprehensive program of facilities management includes a facilities audit—a determination of the physical condition and functional adequacy of the facilities. The audits employed by different institutions vary. Some are extremely comprehensive, designed to assess general building conditions and gather specific data such as component manufacturers and service frequencies. Others are more general, intended to gather information regarding the overall condition of the facilities, their suitability to use, and any major safety hazards or regulatory noncompliance that may exist.

Guidelines for performing an audit are as varied as the results obtained. The facilities audit assesses the structural and functional strengths and weaknesses of a facility. The assessment of condition leads to establishing priorities for allocating effort and funds to correct the detected inadequacies. This evaluation requires two elements to ensure its validity and value: (1) consistency based on codification and ease of use, and (2) dedication of "expert" personnel to follow the audit through to its completion. The term expert is to be interpreted in the broadest sense. A team of consultants could perform this audit. Experienced agencies are available and are increasing in number. On the other hand, the best experts are often on the plant department staff. They are the custodians, electricians, carpenters, draftsmen, and others whose daily activities find them in constant contact with the facilities under investigation. Given a usable, understandable survey instrument or guideline, employees can be the eyes, ears, and brains of the data collection process. Because they are usually the first to hear about a repair need, their findings can be more comprehensive in many areas than more objective experts.

Direct involvement by the plant administrator is helpful, though it need not be intensive. John Brodie, one of the first million-dollar quarterbacks, was asked why he held the football for field goals and extra points. "Well," he said, "I suppose if I didn't hold it, it would fall over." The facilities audit is one area in which plant administrators need to help hold the ball. The efforts of staff personnel may need to be augmented by trained personnel looking for problems that might escape the untrained observer, such as buried piping.

First decide whether the audit will be done by in-house staff, by an outside agency, or a combination. The scope of the project and any special urgency, such as legislative sessions or upcoming board meetings, influence this decision.

Then determine the number of facilities and the extent of attention to be given each. Floor plans, operation and maintenance manuals, repair and maintenance logs, and other useful historical data should be assembled for the benefit of the audit team. Next the audit instrument must be developed. It is possible to design a document from scratch, but samples of audit guidelines used by many institutions are available upon request. Especially valuable are those used by Purdue University and the states of Mississippi, Tennessee, and Ohio. A useful document is Dr. Harvey Kaiser's *Facilities Audit Workbook* available from APPA.[3]

4.4 MANAGEMENT SYSTEMS TO CONTROL DEFERRED MAINTENANCE

Facilities managers know that institutions are prone to respond to fiscal difficulties by deferring needed maintenance for existing facilities. Most also know that the long-run costs are high when an institution consumes its capital for a short-run benefit. Unfortunately, few managers have had the resources at their disposal to convey their concerns to upper level administrators and state officials. Institutions lack the management systems that could help document an institution's backlog of deferred maintenance and the long-run costs of neglecting facilities.

States, colleges, and universities throughout the United States have tried to address the deferred maintenance problem. Institutions have undertaken audits to identify the backlog of work necessary to bring facilities to a reliable state of repair. Most of these studies have shown dramatic physical plant maintenance deficiencies. A University of Nebraska survey prepared in early 1976 showed a backlog of work of $21 million. A further survey of state facilities by a Nebraska legislative committee showed a backlog of deferred statewide maintenance of almost $40 million. At Syracuse University a 1970 deferred maintenance audit identified $18 million of backlogged work. A 1979 survey of the State University of New York outlined almost $27 million of unfunded rehabilitation projects. The University of Missouri has identified an estimated $100 million in deferred renewal, replacement, and energy projects needed to bring facilities into satisfactory condition.

Despite the usefulness of surveys in documenting the magnitude of an institution's deferred maintenance problem at a particular time, most have not realized their potential as the starting point for a total deferred maintenance information system. The ongoing management systems needed to update surveys and organize information in ways meaningful to managers have been neglected. Most institutions can point to one or more audits that provide historical snapshots of deferred maintenance requirements. Obsolescence and irrelevance are chronic problems with one-time audits not part of an ongoing system.

A Comprehensive Facilities Management Program

Institutions and state agencies that have initiated facilities surveys conclude that programs of regular, scheduled, or preventive building maintenance must be developed as part of a comprehensive approach to maintaining facilities. To justify requests for adequate maintenance funding, facility maintenance programs must be organized to prevent further deterioration after deferred work is completed. Preventing future deferral of work (and the resultant increased costs of repairs or construction of new replacement facilities) requires a comprehensive facilities management program. Addressing deferred maintenance is one component of such a comprehensive management system.

The major components of a comprehensive facilities management system include capital budgeting, construction, fuel/utilities, property, planning and design, and maintenance and operations. Figure 4-1 lists the basic objectives of such a system. An effective facilities management system should be tailored

Figure 4-1

Objectives of Facilities Management System

- To provide management with accurate, timely, and consistent information that will enhance the decision-making process.
- To establish uniform procedures and definitions.
- To encourage long range capital planning.
- To enable rapid updating and retrieval of information on condition, size, location, capacity, utilization, and other attributes of facilities.
- To serve as the information base for preventive maintenance scheduling, job order assignment, costing, etc.
- To accomplish specific tasks such as—
  - Maintain an easily sorted file of needed maintenance and repair, energy conservation, life safety/code compliance, handicapped accessibility, and minor renovation projects.
  - Identify all facility projects in terms of building, campus, and/or site affected.
  - Classify facility projects by type of work involved and portion of the building/structure affected.
  - Attach current dollar figures to the costs of all facility projects.
  - Eliminate hand preparation of budget request documents.
  - Track the expenditure of funds on facilities projects.
  - Build historical files of work performed on facilities.
  - Project expenditures necessary to maintain facilities properly in future years.
  - Enable more efficient utilization of facilities.

to an institution. The nature of the program must consider the specific nature of the institution, how it is staffed and organized, how funds are acquired and allocated, and how the program is managed.

Despite institutional peculiarities, a complete facilities management system has certain characteristics. A complete system requires an inventory of existing and proposed facilities, a summary of existing physical and functional conditions, and a projection of future requirements. Included in the inventory are the buildings, land, grounds, and utilities of an institution and the work required to operate, maintain, and bring the facilities into sound condition. Such a system allows an institution to utilize facilities efficiently, organize operations under efficient management techniques, identify safety needs, and monitor an energy program. Finally, a facilities management system can result in greater physical plant efficiency, increased funding due to better documentation of maintenance needs, and an enhanced ability to track expenditures.

Need for Automation

A comprehensive facilities management system could be implemented using familiar manual techniques, but manual systems are difficult to maintain and do not lend themselves to sharing by dispersed users. Manual operations are labor intensive by definition and may contain unacceptable delays in retrieving specific information or in preparing analyses and reports. An effective, automated system saves valuable staff time; is readily shared by different users; and is well-suited to rapid retrieval, updating, analysis, and reporting of information.

An automated system has the added advantage of interfacing, or sharing information, with other computerized systems an institution may have in place. This eliminates a costly duplication of effort and furthers the use of consistent information. Many institutions have computerized systems for student information, payroll/personnel data, financial accounting, and accounts payable. The ability to "talk" to these other systems gives the facilities management system the flexibility to combine facilities data with other relevant information. Facilities managers can turn to a single source for most of their information needs.

Entering the data and maintaining it in the computer is only a beginning. While managers may be interested in individual pieces of information from the data base, they are usually interested in analyses, summary reports, and actual costs. An automated system allows manipulation of individual pieces of data necessary to produce summary reports and analyses. These reports may be retrieved on-line using a computer terminal, may take the form of computer printouts, or may use the computer's graphics capabilities to produce pictorial summaries.

General Requirements of a Comprehensive Program

The expression, "garbage in, garbage out" underscores the point that no automated system can be any better than the basic information it contains. All of the computer resources and programming skill in the world cannot make good information out of bad. If the information requirements a system seeks to meet are poorly conceived, the system may be effectively worthless despite technical excellence.

One principle should apply to an effective deferred maintenance information system: the information collected should relate to specific activities required to bring a facility into acceptable condition, and not to subjective overall condition ratings.

Numerous deferred maintenance audits have been undertaken by states, colleges, and universities using subjective condition rating schemes. A facility may be assigned an arbitrary number of points (say 100) from which auditors deduct for deficiencies. By contrast, specific project information reduces the level of subjectivity and provides detailed data on the appropriate response to a particular deficiency. Rather than pass along a rating, an auditor notes "failed roof." This increases the information content of the data collected.

A slightly more ambitious system asks the auditor to collect some information on the resources needed to remedy the problem. For example, the auditor might note, along with "failed roof," the area of the roof and the type of roofing system in place. Knowing the total area of roofs requiring replacement helps managers budget and request funds. Knowing the types of roofing systems in use at an institution and their failure rates helps management document the deficiencies of particular systems. This in turn helps the institution deal with roofing manufacturers and enables management to make well-informed decisions for future purchases. This illustrates how, by requiring only two pieces of specific project information, an institution can increase the information content of the data collected and how this increased information content can lead to benefits in both budgeting and procurement.

More computer resources are required to enter and store more detailed information. This is a cost of collecting specific project information as opposed to subjective condition ratings. This cost is minimal since most institutions have access to cheap computing power. Even the smallest institution can justify the purchase of a microcomputer to manage facilities information.

More information may also be required of the auditor in the field using a survey oriented toward specific projects. This may be a cost of collecting project-specific information. Subjective rating schemes require auditors to make complex judgments about a facility. They may find it easier to collect a few specific details about a problem.

A final objection to the collection of project specific data is that an institution may be required to provide condition ratings to the state or other governing agency. While it is generally impossible to go from subjective ratings to project specifics, it is possible to program a computer to convert specific information into overall ratings. The computer is as capable as the field auditor of deducting 30 points from a building's total for a failed roof. Indeed, the computer may have a significant advantage over the field auditor in applying a rating scheme since, for all their limitations, computers are especially adept at consistently applying a set of complex decision rules in an unbiased manner.

Specific Requirements of Comprehensive Computerized Program

The specific information needed for an effective deferred maintenance program falls into four major categories: a Basic Facilities Inventory, a Facility

Component and Major Equipment Inventory, a Maintenance Project and Capital Budget Inventory, and Physical Plant Files.

Basic Facilities Inventory Virtually every institution, public or private, maintains a basic facilities inventory to satisfy state and federal reporting requirements. A program accepted by many institutions was established under Title I of the Higher Education Facilities Act of 1963. In 1968 the United States Office of Education published *Higher Education Facilities Inventory Classification Procedures Manual.* The first edition was used by state facilities commissions to determine reporting requirements. Since most institutions lacked any facilities management system, the procedures contained in this manual became the prototype for systems around the country. Subsequent revisions of the manual, such as the 1972 revision by the National Center for Higher Education Management Systems (NCHEMS) at the Western Interstate Commission for Higher Education, became the standard for higher education. (Figure 4-2 Data Elements of Basic Facilities Inventory)

Facility Component and Major Equipment Inventory A further refinement necessary to track maintenance history and the condition of facilities is a Facility Component and Major Equipment Inventory. This inventory builds upon the Basic Facilities Inventory. The two systems are compatible so the computer can relate detailed information about facility components and equipment back to the general building and room data in the Basic Facilities Inventory.

The Facility Component and Major Equipment Inventory can be subdivided into seven major categories of information: building exteriors, room interiors, electrical distribution systems, heating/air conditioning systems, air handling systems, elevators, and plumbing. Figure 4-3 lists the data elements of Facility Component and Major Equipment Inventory.

Maintenance Project and Capital Budget Inventory By themselves, the Basic Facilities Inventory and the Facility Component and Major Equipment Inventory do not provide a complete description of the actual condition of facilities. The Maintenance Project and Capital Budget Inventory closes this gap. This inventory is derived from an initial comprehensive audit of facilities and updated by subsequent review audits. Since the audits focus on specific projects required to bring facilities into acceptable condition, they can be fed directly into the capital budget process. This means that review audits should be conducted at least annually. There are two types of data in this inventory: project records provide an overall description of needed projects (Figure 4-4), and detail records provide a breakdown of specific activities of materials required to complete a particular maintenance project. Detail records provide the information necessary to perform cost estimating for budgeting purposes (Figure 4-5).

Figure 4-2

Data Elements of Facilities Inventory

- Building Data
  - Institution and campus name
  - Building identifying code
  - Building name
  - Construction date
  - Original cost of building
  - Remodeling dates
  - Remodeling cost (total of all remodeling of $50,000 or more)
  - Current replacement cost of the building
  - Type of construction
  - Gross square feet of the building
  - Net square feet of the building
  - Net assignable square feet
  - Accessibility to handicapped
  - Type space: permanent, temporary, rental
  - Ownership code
  - Building functional use

- Room Data
  - Room number
  - Building name
  - Floor designation
  - Area of room, square feet
  - Student station capacity
  - Room use type
  - Actual number of seats in room
  - Handicapped accessibility
  - Floor type
  - Plant Maintenance and Operation Cost code
  - Department assigned to space

As projects are requested and funded, the amount of funding is added to the project record. A link to an institution's financial accounting system allows managers to track the funds associated with specific projects, and the maintenance program as a whole, while work is in progress. As projects are completed, this fact is indicated on the project records, but the *projects are not deleted,* since deleting the projects would involve the loss of valuable maintenance histories.

Figure 4-3

Facility Component and Major Equipment Inventory

- Building Exterior
    - Campus
    - Building Number
    - Type Structure
        - Frame
        - Shell
        - Date Tuckpointed
        - Painted
    - Roof
        - Structure
        - Type
        - Square Footage
        - Insulation/R-Value
        - Date Installed
        - Date Recoated
    - Coping Stone Caulked
    - Drainage System Replaced
    - Windows
        - Type
        - Size
        - Number

- Room Interior
    - Campus
    - Building Number
    - Floor
    - Room Number
    - Room Use
    - Floor
        - Structure
        - Covering
        - Square Feet
        - Installed/Painted
    - Ceiling
        - Square Feet
        - Installed/Painted
    - Wall(s)
        - Structure/Square Feet
        - Covering/Square Feet
        - Date Installed
    - Lights
        - Fixtures
        - Wattage Code
        - Number of Units
        - Installed
        - Comments

- Electrical Distribution Systems
    - Campus
    - Building Number
    - Room Number
    - Floor Number
    - Main Distribution Panel
        - Capacity: Amps
        - Capacity: Voltage
        - Date Installed
    - Circuit Breaker Panel
        - Panel Number
        - Number
        - Capacity: Amps
        - Capacity: Voltage
        - Date installed
    - Comments

- Heating/Air Conditioning Systems
    - Campus
    - Building Number
    - Room Number
    - Floor Number
    - Type Equipment
    - Equipment Number
    - Manufacturer and Model
    - Capacity
        - Horsepower
    - Power Rating
    - Date Installed
    - Date Overhauled
    - Comments

- Air Handling Equipment
    - Campus
    - Building Number
    - Room Number
    - Floor Number
    - Type Central Air System
        - Main Unit
        - System Unit
        - Equipment Number
        - Manufacturer and Model
        - Capacity
        - Static Pressure
    - Coil(s)
        - Type
        - Capacity
    - Fan Motor HP
    - Filter Type
    - Filter Size
    - Number of Auto Dampers
    - Comments

- Elevators
    - Campus
    - Building Number
    - Elevator Type
    - University Number
    - Manufacturer and Model
    - Number of Floors
    - Emergency Power
    - Handicapped Access
    - Comments

- Other Equipment
    - Campus
    - Building Number
    - Room Number
    - Floor Number
    - Type Equipment
    - Equipment Number
    - Manufacturer and Model
    - Capacity
        - Horsepower
    - Power Rating
    - Date Installed
    - Date Overhauled
    - Comments

Figure 4-4

Maintenance Project and Capital Budget Inventory: Project Record

Entry Element	Example
Entered	(MP)
Prepared by	(J. P. Jones)
Reference Number	(4000169)
Description	(MOD to comply with Fire & Safety Codes)
Campus Number/Name	(38/Rolla)
Site	(00)
Building Number/Name	(064/Stewart Hall)
Class Number/Name	(0/Preservation)
Type Number/Name	(01/Building Exterior)
State/Local	(5)
Capital/Operating	(C)
External Design Assistance	(A)
Fiscal Year Requested	(85)
Priority	(A)
Energy Saving	(Blank)
Payback	(Blank)
Job Project Number	(82-1243)
Stage	(A)
Date Prepared	(January 10, 1983)
Justification	(Interior damage due to water seepage through walls requires exterior face of building be tuckpointed and waterproofed.)

Figure 4-5

Maintenance Project and Capital Budget Inventory: Detail Record

Entry Element	Example
Action	(REP)
Size/Description	(WATERPROOF BRICK)
Item Number/Name	(11001/EXTERIOR SURFACE BRICK)
Number of Units	(415SF)
Unit Cost	(2.83)

Field Audit

Field work should be the last aspect of a deferred maintenance information program to be considered. If information requirements and applications are not planned before field work begins, the most motivated field personnel will not be able to provide meaningful and useful information.

Need to Coordinate with Data Entry An effective field audit is coordinated with data entry. (A computer generated data entry form is illustrated in Figure 4-6.) Gathering the data on standardized forms ensures uniformity of the information collected and eliminates the need to transfer field reports into a format usable for data entry. Entering data as soon as possible after they are collected enables management to monitor the progress of the audit and permits auditors to verify the data received by the computer while the experience is still fresh in their minds. See the turnaround document illustrated in Figure 4-7.

The ideal system permits auditors to enter information directly into the computer. Auditors log on to the computer at a terminal, select an appropriate data entry screen and simply type information directly into the computer. The key to an interactive system is to provide a friendly method by which the computer can prompt the auditor to tell it what particular information is to be entered. A menu-driven system meets this requirement.

A menu-driven computer interacts with the auditor by displaying a list or menu of choices. The computer then reads the selection entered and takes the appropriate action. This action may be to display a data entry screen or it may be to display additional menus providing more detailed choices. Figures 4-8 and 4-9 illustrate typical menus and data entry screens.

Areas to be Addressed by a Field Audit Although a field audit can be limited to maintenance projects, a complete audit of needed projects can be accomplished at the same time with little additional effort. Figure 4-10 outlines the areas addressed by a complete field audit.

Instructions for Auditors Much needless work required to translate field reports into usable information can be avoided if auditors are familiar with the particular way the deferred maintenance information system arranges data and with the coding systems that are used. A packet of field instructions, supplemented by brief training sessions for field personnel, can help avoid work necessary to "clean up" field reports.

Figure 4-6

Computer Generated Entry Form

DATA ENTRY SHEET FOR NEW PROJECTS TO FOCIP I FILE

ENTERED :______
PREPARED BY :______________________________
DATE :___/___/___

REF. NUM: ______________
DESC: ____

CAMPUS:	___-(__________)	ACSC:	_(A=yes Blank=no)	---- JUSTIFICATION ----	
SITE:	___-(__________)	FY REQUESTED:	___		____________________
BUILDING:	_____-(__________)	PRIORITY:	___ (A,B,C,D,E)		____________________
CLASS:	_-(__________)	ENERGY SAVINGS:	_.___ BTU/SF/DD		____________________
TYPE:	___-(__________)	SIMPLE PAYBACK:	_._		____________________
FUND(S/L):	_(S=State L=Local)	JO/PROJ :	_________		____________________
C/O:	_(C=Cap O=Opr)	STAGE:	_		____________________

INDIVIDUAL ITEMS

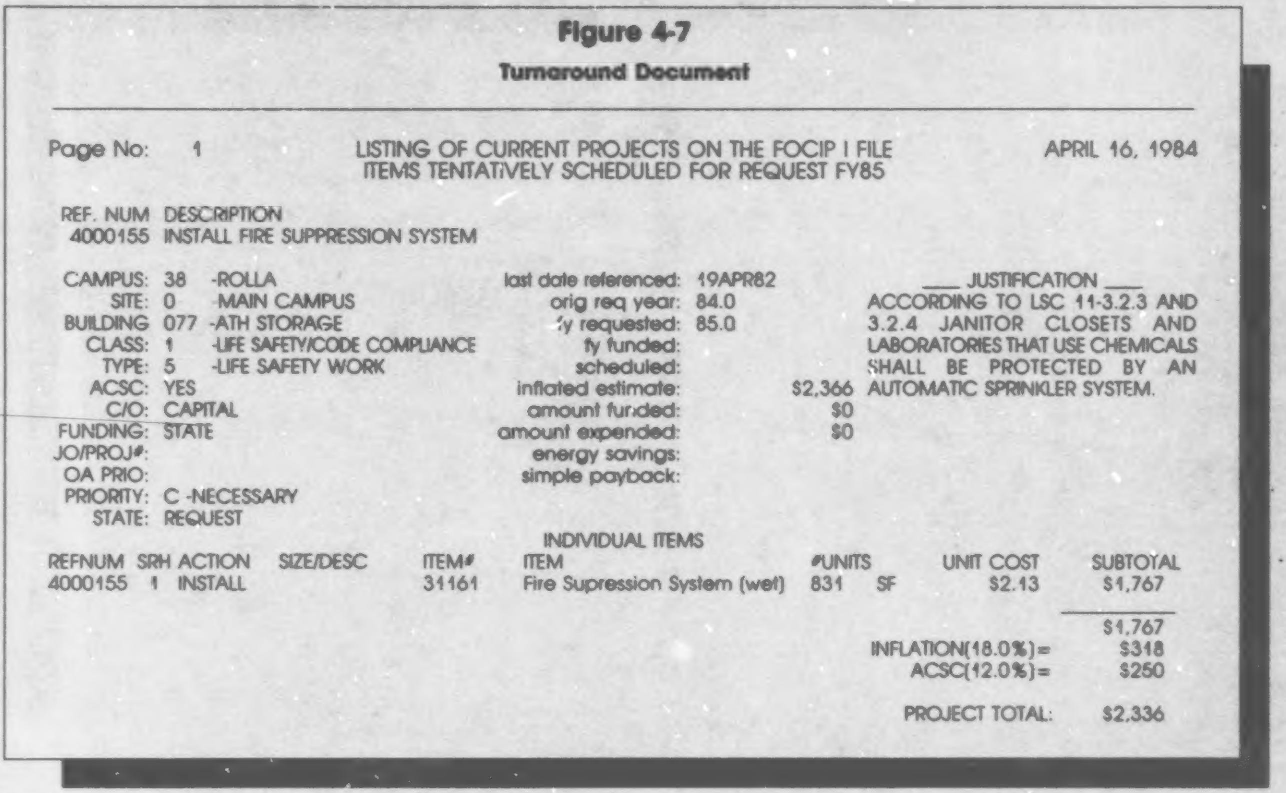
SRH	ACTION	SIZE/DESC	ITEM#	ITEM NAME	#UNITS	UNITS	CUST UNITS
_	___	_______	_____	(______________________________)	_____	(___)	_________._
_	___	_______	_____	(______________________________)	_____	(___)	_________._
_	___	_______	_____	(______________________________)	_____	(___)	_________._
_	___	_______	_____	(______________________________)	_____	(___)	_________._
_	___	_______	_____	(______________________________)	_____	(___)	_________._

CLASSES
0=PRESERVATION
1=LIFE SAFTEY/CODE
2=HANDICAPPED I
3=HANDICAPPED II
4=ENERGY
5=CAP IMPROVEMENT
6=NEW CONSTR.
7=HAZ. WASTE
8=MJR. RENOVATION
9=CAPITAL EQUIP

TYPES
00=ROOFS
01=BLDG EXT
02=BLDG INT
03=MECH/PLUM
04=ELECTRICAL
05=LIFE SAFETY
04=EXT SITE
05=UTILITY DIST
06=POWER PLANT

Figure 4-7

Turnaround Document



Page No: 1

LISTING OF CURRENT PROJECTS ON THE FOCIP I FILE
ITEMS TENTATIVELY SCHEDULED FOR REQUEST FY85

APRIL 16, 1984

REF. NUM DESCRIPTION
4000155 INSTALL FIRE SUPPRESSION SYSTEM

CAMPUS: 38 -ROLLA
SITE: 0 -MAIN CAMPUS
BUILDING 077 -ATH STORAGE
CLASS: 1 -LIFE SAFETY/CODE COMPLIANCE
TYPE: 5 -LIFE SAFETY WORK
ACSC: YES
C/O: CAPITAL
FUNDING: STATE
JO/PROJ#:
OA PRIO:
PRIORITY: C -NECESSARY
STATE: REQUEST

last date referenced: 19APR82
orig req year: 84.0
fy requested: 85.0
fy funded:
scheduled:
inflated estimate: $2,366
amount funded: $0
amount expended: $0
energy savings:
simple payback:

____ JUSTIFICATION ____

ACCORDING TO LSC 11-3.2.3 AND 3.2.4 JANITOR CLOSETS AND LABORATORIES THAT USE CHEMICALS SHALL BE PROTECTED BY AN AUTOMATIC SPRINKLER SYSTEM.

INDIVIDUAL ITEMS

REFNUM	SRH	ACTION	SIZE/DESC	ITEM#	ITEM	#UNITS		UNIT COST	SUBTOTAL
4000155	1	INSTALL		31161	Fire Supression System (wet)	831	SF	$2.13	$1,767

	$1,767
INFLATION(18.0%)=	$318
ACSC(12.0%)=	$250
PROJECT TOTAL:	$2,336

Figure 4-8

Typical Master Menu

```
SELECT APPLICATION
     1  FACILITIES    —  BASIC FACILITIES INVENTORY
     2  FOCIP         —  MAINTENANCE PROJECT AND CAPITAL
                         BUDGET INVENTORY
     3  FOCIP 2       —  FACILITY COMPONENT AND MAJOR
                         EQUIPMENT INVENTORY
     X  EXIT          —  END SESSION

PRESS END KEY TO TERMINATE

                          FOCIP
SELECT APPLICATION
     1  PROJECTS      —  BROWSE PROJECT DATA
     2  DETAIL        —  BROWSE DETAIL DATA
     3  UPDATE        —  FOCIP DATA ENTRY TO UPDATE
                         EXISTING PROJECTS
     4  NEW           —  FOCIP DATA ENTRY FOR NEW PROJECTS

PRESS END KEY TO TERMINATE
```

Figure 4-9

New Project Information

```
CAMPUS

REFERENCE NUMBER
DESCRIPTION
SITE
BUILDING NUMBER
CLASS
STATE
TYPE
STATE / LOCAL
CAPITAL / OPERATING
ACSC
REQUEST YEAR
PRIORITY
ENERGY SAVINGS
PAYBACK
JOB PROJECT NUMBER
STAGE
```

Figure 4-10

Areas to be Addressed by a Field Audit

- Maintenance and Repair/Preservation. Non-routine repair and maintenance work performed to ensure that the useful life of a facility or building element is not reduced below that which it was orignally designed. Preservation is limited to work done in cycles of longer than one year, excluding work which substantially improves or increases the value, capacity, or useful life of a facility or building element.

  Presevation projects can be classified into the following subtypes:

  Roofs. This category includes partial and total roof replacement, bituminous coating, repair and replacement of roof support, decking, drainage systems, parapets, and insulation (when part of a roof replacement).

  Building Exteriors. This category includes interior painting and the repair/maintenance of walls and partitions, floors and floor coverings, ceilings, interior doors and stairways, and major fixed equipment.

  Mechnical and Plumbing. This category consists of the repair and maintenance of mechanical and plumbing systems within a structure.

  Electrical. This category consists of the repair and maintenance of electrical distribution systems within a structure.

  Life Safety and Security Systems. This category consists of the repair and maintenance of *existing* life safety and security systems.

  Exterior Site Work. This category consists of the repair and maintenance of exterior drainage systems, sidewalks, retaining walls, steps, and road repairs that are unconnected to a particular building (more than five feet outside the building perimeter).

  Utility Distribution Systems. This category consists of the repair and maintenance of utility distribution systems located five feet or more outside the building perimeter.

  Power Plant. This category consists of the repair and maintenance of major fixed power plant equipment.

- Life Safety and Code Compliance. Renovation items in this category include work necessary to bring facilities up to fire and safety code standards (NFPA 101, BOCA, etc.) as adopted by the institution.

- Major Renovation. Items included in this category should be major remodeling and renovation projects. Such multifaceted projects do more than simply re-define interior space and may involve changes in bearing walls or in electric, heating, plumbing, or other systems.
- Energy Management. Energy management projects include installations of energy control and management systems and modification of building or distribution systems to increase energy efficiency.
- Compliance with State and Federal Regulations. Handicapped accessibility. This category includes projects designed to make programs accessible to the handicapped, ANSI 117.1.
- Hazardous Waste Requirements. This category includes projects necessary to bring the institution into compliance with state and federal regulations in the handling and treatment of hazardous waste.
- New Building Construction. This category includes the construction of new, permanent facilities.

4.5 PRESENTING THE CASE

All of the work in the world to define the problem and assess its scope will be of little value if there is no funding to implement the necessary action. In an atmosphere of full cooperation, funding is no problem and the administrator must simply present his or her amended budget and begin the next step in the process. If, however, this is not the case, then the reason for the resistance must be isolated and addressed. In a survey of institutions with more than 6,000 students enrolled, almost 40 percent of the plant administrators indicated that funding for deferred maintenance is included in the regular maintenance budget. Since these were mostly respondents who had indicated that no deferred maintenance funding existed, these institutions expect to catch up on deferred maintenance without any additional funding to make that possible. Over 28 percent of the respondents indicated that their institutions could not afford it or that their legislatures did not think they could. About 29 percent cited administrative short-sightedness as the key to the lack of funding—an indictment of our ineffectiveness as facilities administrators and educators. Almost 30 percent indicated that one of their biggest problems was establishing a credible dollar estimate and then presenting the case well. Less than 10 percent said they didn't need funding, while 11.2 percent acknowledged that they had not asked.

As a strategist, the administrator must be aware of these common pitfalls and ways to avoid them. He or she must present defensible cost figures and be able to show decision makers why they cannot afford not to fund the program. In making a presentation the administrator or staff members must become a host of characters—politician, lobbyist, counselor, engineer, accountant, devil's advocate, and vicar. The proposal will be vying for priority with a myriad of other ideas and proposals. Many of these competitors may be the pet projects of others in the decision-making body. When this is the case, they may be fighting as much for their own proposal as against yours. This is where lobbying and other political dynamics come into play. This process is probably not new to the experienced administrator who has often traded votes, consciously or unconsciously.

Once the political climate is set, it becomes apparent that the plant administration's is no ordinary proposal. In the first place, there are those elements of definition that give the administrator something with which to condemn the failures of others (guilt). Additionally, the scope of funding equals 5, 10, as much as 20 percent or more of the institution's annual budget. Finally, unless the decision makers are more knowledgeable than average, there will be a substantial information gap between the harsh realities of the problem and their perceptions.

The first concern is resolved by carefully wording the problem statement (definition). It may be handled any number of ways, but the most important point is that everything wears out sooner or later. Wording that has had a measure of success suggests *elective* measures that have been *postponed*. The seriousness of the situation need not be compromised, while the need for increased future funding can be demonstrated. Obscure, although accurate, examples can be mentioned, such as preventive maintenance measures and obsolescence determinants that were not cost effective a few years ago, but are now, due to the inflation of various costs.

Another important element of the problem statement is incorporation of the "big club" phenomenon. This is the practice of giving added credibility to a thought, department, or process because it is in vogue. Others call it striking while the iron is hot. Routinely, different elements within the community are recipients, usually unwittingly, of the benefits of this syndrome. This becomes apparent when the school is being visited for accreditation. Ask the administrators where the funding emphasis, and the dedication of personnel efforts are being placed. Then go back just before the scheduled follow-up visit by the team chairperson and ask the same question. The answers will certainly have changed, and the "big club" will now belong to the department needing attention.

In the maintenance discussion, the "big club" must be passed to the hands of the facilities personnel with the support of the chief financial officer. While they own the club, they can gain the funding necessary and implement programs of preventive maintenance that will last for years to come.

4.6 MANAGING THE MAINTENANCE PROGRAM

Recognizing that the odds of selling a program and getting it funded are probably better now than they have ever been before, Seldon Kempton of

California State Polytechnic University said, "We must organize our departments and run them in a professional manner. We must teach those who allocate the funds. We are the ones who know the problem, and we are the ones who must educate others in the solution. It's a challenge we must meet if we are to be successful in properly maintaining our facilities. We have never had a better chance, nor has there ever been a more opportune time."[4]

Deferred maintenance has taken many forms. It exists not only with our facilities but also with our personnel. Many life-long educators express a need to change careers, saying they are "burnt out." Also deferred is an injection of creativity into programs. Too often faculty members say, "Next year I'll completely rework my lectures and exams." But next year never seems to arrive. Administrators defer revamping organizational structures, thus perpetuating ineffective systems. Libraries defer purchases of needed volumes and the viability of their holdings begin to slip, almost imperceptibly. We only fool ourselves when we believe things will be better tomorrow. Deferring needed work is not at all unlike that of the debtor who attempts to borrow himself out of debt, and who only succeeds in mortgaging the future.

Not to seize this opportunity to reverse the trend in the area of deferred maintenance would be a shame. To secure funding and then fail to do the job well, or to do it and fall back, would be criminal. We must recognize our responsibility to coming generations who stand to lose the most if we continue to defer problems rather than solve them. On this front, the plant administrator can step forth and lead the campus community.

END NOTES

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2. J. Peyton Fuller, associate vice president and corporate controller, Duke University, "Deferred Maintenance Financing" (unpublished, Washington, D.C.: Association of Physical Plant Administrators of Universities and Colleges, 1980).
3. Harvey H. Kaiser, *Facilities Audit Workbook* (Washington, D.C.: Association of Physical Plant Administrators of Universities and Colleges, 1982).
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CHAPTER 5

Management of Maintenance Stores

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5.1 INTRODUCTION

Every maintenance enterprise requires that a supply of materials be available to workers. Even the owner-operated corner filling station must have its supply of fan belts, hoses, spark plugs, tire patches, and motor oil. In a small operation, such as that, the owner-operator may not have a sophisticated system for managing the stock of supplies, yet he or she understands how essential those supplies are to the business's success.

If additional employees are involved, the availability of a readily accessible stock of supplies is critical to the productivity of each person involved in the maintenance task. Similarly, the satisfaction of the clientele is intricately linked to the quantity, quality, availability, and cost of materials used in the work.

As the mission of the maintenance enterprise grows in size and complexity, so does the requirement for a well-managed stock of maintenance supplies. Certainly the plant department at the smallest college is vastly more complex than the corner filling station. If the campus consists of only one building, there are many dimensions to the maintenance task. Every element of every building presents a different set of problems to those charged with maintenance of the facility. There are structural, mechanical, and electrical elements. There is roofing, flooring, glazing, hardware, machinery, controls, lighting, power panels, elevators, and the list goes on. At larger institutions the quantity and variety of the required maintenance stock grows, too. And as the number of persons engaged in the maintenance of the facility grows larger, it becomes even more incumbent upon plant administrators to see that each worker is adequately supplied with the materials he or she needs.

Most maintenance people are skilled in one or more trades. Their services command a relatively high wage. They expect to be provided with the right tools, equipment, and supplies to enable them to do their work properly and without delay. Quality maintenance tradesmen take pride in their work. Motivation and productivity can be kept at a high level only if the maintenance manager provides these employees with efficient logistical support.

College and university facilities receive heavy use. Evening and weekend classes, seminars and workshops add to the normal weekday hours of operation. There is little downtime available for maintenance and repairs, indoors or out. Our clients are the students, faculty, and staff. They are a discerning and demanding group of people. All of these factors combine to make it essential that a readily-accessible stock of maintenance supplies be available at all times.

Scope

Maintenance supplies must be kept in a secured place. The storeroom must be arranged and organized so that all items can be quickly stocked, located, checked out, and accounted for. Whether the storeroom is large or small depends upon the quantity and variety of stock involved. It is unwise to have supplies on hand, even in a secured area, without a well-defined management system in place to control the storeroom and the stock therein.

The management of maintenance stores is essential to a successful operation. This responsibility should never be left to the maintenance personnel or their supervisor(s). It deserves its own manager to implement the appropriate policies and procedures and oversee the daily operation of the storeroom, which may include a staff of stores personnel.

Stores Stock

Several kinds of materials and supplies are normally kept in stock. These broad categories usually hold true regardless of the size of the institution served.

Routine Maintenance Items These are supplies that are required frequently to keep things in good repair. There may be hundreds of items in this category, such as lamps, wire, switches, outlets, breakers, glass, paint, locks, hardware, screws, nails, valves, thermostats, refrigerant, etc. These items can be categorized further into trade sections such as Electrical Maintenance Supplies, Mechanical Supplies, Carpentry Supplies, etc. It may be useful to catalog them that way.

Spare Parts These are special purpose items that are used for repairs to specific installed equipment on the campus. Usually they are replacements for parts that are expected to wear out in service. Power plant, air conditioning, and laboratory equipment are critical to any campus operation. The manufacturers of all such machinery and equipment recommend that certain service parts be kept on hand. After deciding which spare parts to have on hand, the parts should be purchased and placed under the control of the maintenance stores system. There they can be kept in good condition, listed in the stock catalog, and available upon a moment's notice.

Janitorial Supplies Housekeeping is a never-ending, daily task in every college and university building. A large quantity of standard supplies is used annually. These items can be purchased most economically if ordered in large quantities such as case lots and drums. A section of the storeroom should be set aside for bulk quantities of supplies of this type. Typical examples are floor wax, stripper, rags, paper towels, toilet tissue, soap, mops, and buffer pads.

These items must be stocked and dispensed through a properly managed stores system. Because housekeeping is extremely labor intensive, lack of any needed supply item can be counterproductive in terms of wasted housekeeper time. In addition, the items are useful in every home. Central control and accountability are needed to help minimize pilferage.

Nonmaintenance Items The plant mission may include much more than maintenance and repairs. It may encompass minor alterations and construction tasks. If so, it is desirable to stock items that are usually required to support this activity such as steel studs, fire-rated sheetrock and fasteners, ceiling panels and ceiling grid components, pipe, conduit, light fixtures, ductboard, insulation, etc. Caution must be exercised to prevent overstocking. Large scale construction projects should not be supplied from the storeroom. Instead the materials should be ordered specifically for the job.

Tools Expendable tools may be stocked in the storeroom to assure replacement when required by the maintenance staff. When handled this way, storeroom managers exercise control that minimizes excessive loss or theft.

The storeroom and stores personnel may operate a tool crib. Special tools not normally assigned to individual shops or tradesmen can be kept in stock and checked out to individuals when needed. Tools can be accounted for, and the optimum number of special purpose tools can be available to everyone on demand. The stores personnel inspect the tools when they are returned to the storeroom. Personnel can also be trained to keep special tools in good repair, sharpened, etc. Worn-out tools are identified and replaced. By using the storeroom this way, maintenance supervisors and their staff are relieved of this responsibility. They are able to be more productive at their maintenance tasks. Tools likely to be handled this way include large power drills, hydraulic benders, gear pullers, tap and die sets, and ladders.

Economics of Inventory Size

To determine the optimal size of inventory, the stores manager must seek the opinions of plant staff members most knowledgeable concerning the use of the items under consideration. Then the cost of stocking maintenance and non-maintenance items must be balanced against the tangible and intangible losses that occur if the materials are not readily available. The cost of stocking certain items is relatively easy to determine. However, the losses that might occur if the items were not stocked are harder to determine with accuracy. Typical losses are in manpower, job delay, rescheduling of work already in progress, complaints from clients, and reduced motivation and morale among the work force.

Although advice about initial stocking levels should be sought from all quarters, the stores manager should make the final decision for every item. Once an item is placed in inventory in some specified quantity, its actual usage rate can be determined over time. Then the stocking level can be adjusted to achieve the desired turnover interval.

Factors that Increase Stores Inventory

Certain factors, which may or may not be controllable, tend to increase the level of stores inventory. These should be recognized so that maximum control can be exercised where applicable.

- Costs associated with equipment downtime in academic areas, research facilities, etc.
- Inadequate planning and scheduling of projects.
- Economics of quantity purchasing.
- State contract purchasing requirements.
- Lack of parts/material standardization.
- De-centralized stores.
- Lack of nearby or dependable suppliers.
- Little control of inventory and order quantities.
- Response time requirements.
- Purchasing regulations, bidding requirements.

Factors that Decrease Stores Inventory

- "Budget" versus cost of stores operation.
- Efficient purchasing regulations.
- Good service from suppliers.
- Equipment downtime unimportant.
- Importance of response time.
- Good controls on inventory and ordering quantities.
- Centralized stores.
- Limited mission of physical plant.

5.2 ORGANIZATION AND STAFFING

The stores stock must be under the control of a manager who is not involved in the maintenance function. At a small college, the stores manager may handle this responsibility singlehandedly. At larger institutions the manager will require a staff to handle various parts of the work. Clerical staff in the stores office handle all records, reordering of stock, receiving documents, invoices, inquiries, etc. In the stockroom stock clerks are responsible for the issue counter(s). They also stock the shelves with incoming goods, count the stock, write issue tickets to record stock being issued, and do all of the labor associated with the operation of the storeroom. In large storerooms a foreman or storekeeper may supervise the stock clerks and oversee the operation of the storeroom.

Ideally, a single storeroom will suffice. It should be located adjacent—or as close as possible—to the maintenance shop(s). If there are several trades shops, a separate issue counter near each shop is useful. The storeroom should be organized so stock is separated into trade groups. That is, all electrical supplies (whether maintenance or nonmaintenance items) are in one section closest to the issue counter convenient to the electrical shop. Paint supplies should be in a section of the storeroom closest to the issue counter serving the paint shop.

The storeroom should have a shipping/receiving dock to permit loading and unloading directly from trucks. This is especially necessary in operations that are involved in nonmaintenance work and that require stocking large items such as plywood, lumber, pipe, sheetrock, drums, and cylinders.

An outdoor storage yard may be needed for bulk storage of sand, gravel, large pipes, poles, roofing tile, and brick. Special equipment for handling these materials will be required. The materials in the outdoor yard must be secured and placed on the inventory control system just as those in the main storeroom.

On large university campuses it may be necessary to decentralize the stores operation. This is true if the maintenance organization itself is decentralized. There are various ways to do this. For example, maintenance and non-maintenance items may be kept at one stores location, while janitorial supplies are at another location. Stores might be decentralized by trades groups. Or there could be a major storeroom and a minor one located on a branch campus, each containing the same general variety of supplies.

While there may appear to be strong justification for decentralized stores, never select this option without serious consideration. If the stores operation is decentralized, all locations must remain under the same manager and common control system.

Centralized and Decentralized Stores

The following list shows that more factors favor a centralized stores operation than a decentralized arrangement. Still, in specific circumstances the factors that favor the decentralized concept may be dominant.

Centralized Stores

- Stock duplication avoided.
- Fewer personnel required, both supervisory and clerical.
- Reliable inventory control.
- Reliable cost accounting.
- Efficient space usage.
- Better security.
- Practical delivery service and material handling.
- Less support equipment required—dollies, forklifts, etc.

Decentralized Stores

- Less travel and waiting time for craftsmen.
- Closer control of maintenance manpower by line supervisors.

Some of the limitations of centralized stores can be overcome without decentralizing the operation. Delivery service can be provided. This requires high levels of cooperation, coordination, and communication between maintenance staff and stores personnel. On college campuses telephones are everywhere. Many physical plant organizations are now equipped with sophisticated radio systems, thus alleviating communication problems. If used effectively, a delivery system can save manpower in the maintenance function. Maintenance personnel should keep the appropriate section of the stores catalog in their tool kits. They can order supplies by phone using the exact stock number(s). The delivery van must be equipped with a radio.

Another technique for avoiding decentralized stores is to furnish maintenance personnel with stock-equipped service vans. If a van is used for plumbing service, it is stocked with all the items most commonly used every day by the operator/maintenance worker. These supplies are in small compartments on shelves just as in the storeroom. Each bin has the appropriate stock number of the item contained. As the plumber makes service calls, he or she records on the work order slip the stock number and quantity for each item used. At the end of the day the information is used to charge all the items used to the appropriate work orders. Then during the evening the van is restocked with identical materials. This technique eliminates most trips back to the storeroom. Items not in the van are obtained by delivery service as needed.

Another benefit derived from the use of stocked service vans involves evening or weekend emergency service calls. When called out for emergency service the employee takes the service van, which probably has everything needed to handle most problems. This eliminates any reason to enter the storeroom after hours. Again, when the van is restocked, all items used are charged to the appropriate job number.

Reporting Relationships

Plant maintenance stores is a function that must report to plant administration to be effective and efficient. At some institutions the stores function reports to the purchasing department. This seldom works because the goals of the purchasing department are altogether different from that of the plant. The operation of the maintenance stores is closely associated with the physical plant maintenance function.

In this arrangement the purchasing department sets policies, procedures, and controls on the purchase of stock. The accounting department sets policies and procedures for inventory control and transactions between accounts. The plant department staffs and manages the stores operation. At some institutions the purchasing department has granted the facilities stores manager direct authority to issue purchase orders for stock replenishment (within specified monetary limits). Such an arrangement reduces acquisition time and increases the efficiency of the stores operation.

Staffing Requirements

The size of the stores staff is proportional to the size and complexity of the inventory and to the number of storerooms involved (centralized or decentralized).

A small operation (less than 5,000 line items of stock) would probably have—

- 1 manager.
- 1 clerk/typist.
- 1 stock clerk.

A medium-sized operation (5,000 to 8,000 line items of stock) might require—

- 1 manager.
- 2 clerk/typists.
- 1 storeroom supervisor/stock clerk.
- 2 stock clerks.
- 1 delivery van operator.

A large operation (8,000 to 12,000 line items of stock) might need—

- 1 manager.
- 3 clerk/typists.
- 1 storeroom supervisor.
- 3 stock clerks.
- 1 or 2 delivery van operators.

If the stores operation is decentralized, a storeroom supervisor and possibly additional stock clerks will be needed at each sublocation.

5.3 STOCK DETERMINATION

The kind of stock purchased and the quantity of each item vary among institutions depending upon a number of factors. Most important of these is whether or not the materials are easily obtained elsewhere. If the institution is located in a large metropolitan area with numerous wholesale supply houses, it may not be necessary to carry an extensive inventory in the maintenance stores. This is especially true if those suppliers offer a reliable delivery service. (State institutions must consider whether state purchasing contracts permit them to buy from the nearby wholesale suppliers.)

If the institution is located in a remote area, the stores operation may need to be self-sufficient in order to meet the daily needs of the maintenance staff. Institutions engaged in science and technology research demand a short maintenance response time; thus, the importance of well-stocked maintenance stores increases. Then the quantity and variety of stock will increase.

The age of the institution's facilities, the type and kind of utility systems, and the installed building mechanical/electrical systems are reflected in the stores stock inventory. This is especially true in the spare parts category.

Deciding What to Stock

The stores manager must work directly with the maintenance supervisors to develop the initial list of items to be stocked. The task should be approached systematically by establishing broad category checklists, by trades. For example—

- Maintenance items, electrical
  - Fluorescent lamps
  - Ballasts
  - Incandescent lamps
  - Mercury vapor lamps
  - Building wire
  - Circuit breakers
  - Switches
  - Outlets
- Nonmaintenance items, electrical
  - Conduit
  - Cable
  - Junction boxes
  - Light fixtures

Spare parts, electrical
- Contactors
- Brushes
- Relays
- Transformers

This list should be as complete as possible. Each item can be expanded to list the various sizes, styles, and wattages that are needed. Other organization's stores catalogs and suppliers' catalogs are helpful in developing a comprehensive list. But every institution is unique, and maintenance supervisors know each item's importance to his or her college or university.

After the list is complete, managers assign stock identification numbers and establish maximum and minimum quantities. The inventory list should then be reviewed and approved by the plant administrator. Once approved, the inventory lists should not be arbitrarily changed. A procedure should be developed so that any supervisor who wants to add or delete an item from the list can use a form to describe the item, propose an initial maximum and minimum, and give justification for the proposed action. This should be routed to the plant administrator for approval, then forwarded to the stores manager for implementation.

Order Points

As stated above, a maximum and minimum stocking level is determined for every item in the stores inventory. The minimum number that is established is critical. When that number is reached for a given item, there must be a sufficient number in the bin to last until resupplied. This is the order point. Determining the optimum minimum stocking level, order point, is a function of the usage rate and acquisition time. The goal is to avoid stock-outs. Stock-outs occur when acquisition times exceed the number of items remaining in stock divided by the usage rate.

Historical records are the best way to determine usage rates and acquisition times. In the initial stages of stores operation, stock-outs may occur more frequently than later on. Computerized stores inventory systems are especially useful in determining statistically accurate usage rates and acquisition times. Initially the maintenance supervisor's judgment is used to estimate the usage rate, while the stores manager's judgment determines the acquisition time. From this experience the stores manager establishes the initial minimum stock level for each item.

Order Quantities

The maximum number of each item carried on the inventory is based on economical ordering quantities and desired stock turnover interval. The stores manager must determine economical ordering quantities for a given item (each, dozen, gross, case, etc.). The stock turnover interval should be as short as possible while accommodating the preset ordering quantities. The shorter the stock turnover interval, the less capital is invested in stores stock. Capital available for stores inventory will influence decisions about stock turnover intervals per item and for the inventory as a whole.

5.4 CONTROL PROCEDURES

The policies and procedures that govern the daily operation of the stores function include records, documents, and systems. These control measures determine the success of the stores function, as well as the maintenance function. It must be easy for maintenance staff to draw materials from stock, and they should rarely encounter stock-out situations. Materials used must be accounted for and charged to the appropriate work order number or account. Statistical information should be available from stores records. Overall cost of stores materials, including overhead charges, should be minimized. These objectives can be met using various management controls.

Inventory Records

Until recently most stores (certainly small ones) used a cardex system for inventory items and posted all transactions manually. Manual systems were slow and cumbersome, stock-outs and overstocking were commonplace, records were usually inaccurate, statistical information and management reports were almost nonexistent. Computer software and peripheral hardware were complex and expensive. So electronic data processing systems were reserved for "large" stores.

All of this has changed. Almost every stores operation should be computerized. Software is already written or it can easily be tailored to particular needs. Adequate computers (hardware) are relatively inexpensive. If not run independently, a stores program can easily use an existing main-frame computer with a remote terminal and printer. The maintenance stores program should be a subsystem of a larger facilities management system. For example, a labor subsystem can be integrated with a stores subsystem to yield a job-cost system.

With all of this in mind, it is well to begin with a computerized stores system. First develop the total inventory list in the form of a Stores Inventory Status Report (Figure 5-1). Every item has a stock number. This should be a ranked number with meaning to the staff who work with the stock. In the example, the first two digits refer to the trade group (electrical). The next three digits define the type of item (046-switch or 047-tape). The last four digits define the subdetails of the item. This is followed by a clear and concise description of the item and the unit of measure (U/M) by which it is purchased. The next column shows the current balance (number of items in the bin) at the time the report is printed. This is followed by the minimum and maximum established for each item and the number of these items issued during the preceding 12 months. The last two columns show the unit cost of each item and the total current value of the items in the bin.

As items are acquired or sold and entered into the computer, the Inventory Status Report is immediately updated. A hard copy of the status report, or any portion of it, may be generated at any time upon demand. Or any portion of it may be viewed on the computer terminal.

Computerization makes refinement of the usage rates and turnover statistics easier and more precise. When the minimum balance is reached (order point), a separate report is generated to indicate this. Thus, at the end of a day (or any other increment of time) a report can be generated that identifies all stock items that have reached the order point. Purchase requisitions are then prepared for those items. If optimum reorder quantities are programmed, the computer—linked to a word processor—will generate the purchase requisitions.

The Stores Inventory Status Report becomes the stores catalog. It can be placed at the issue counters; parts of it can be distributed to appropriate maintenance staff, estimator's office, etc.; and it can be updated at any time. The dollar value of current inventory (last column) can be summarized at the last page of each subsection (03-electrical) and on the last page of the report for all sections (entire inventory).

Stores Requisitions

It is possible to place a terminal at each stock issue counter and as stock items are dispensed, record the information directly to the computer file, along with the work order number or account to which it is charged and the maintenance person's identification number. It is also possible to become too efficient. With the system just described, all written documentation is eliminated and with it all chance to check for errors or verify information.

A stores requisition form is useful. These can be two- or three-part carbon forms in a dispenser at the issue counter. The maintenance worker or stock clerk can record the stock number and quantity of each item, the work order or account number to which it should be charged, and the employee's identification number and signature. It is not necessary to write descriptions or prices of stock items. The computer is programmed to do that. One copy of the requisition is retained by the recipient, while the other copy is kept at the issue counter. Periodically the clerk/typist in the stores office can enter the information into the computer after checking and verifying any unusual data. The hard copy can be retained in file for a specified period.

Accounting for Material Usage

The computer never tires of keeping track of transactions. It easily segregates all transactions by the account number or work order number to which the

Figure 5-1

Stores Inventory Status Report

STORES INVENTORY STATUS REPORT
02/21/83

PHYSICAL PLANT DIVISION

PAGE- 36

STOCK NO.	DESCRIPTION	U/M	CUR BAL	MIN BAL	MAX BAL	12-MO ISSUE	STK T/O	UNIT COST $	CURRENT INV VL $
03 046 0121	SWITCH, TUMBLER, 'JUNIOR QUIET SWITCH', FOUR WAY, 15 AMP, 120-277 VOLT, AC ONLY, IVORY, HUBBEL #1184-I	EA	5	2	5	4	0.75	6.187	30.93
03 046 0123	SWITCH, TUMBLER, DOUBLE POLE, INTERCHANGEABLE QUIETTE, 15 AMP, 120-277 VOLT, BROWN, HUBBELL#1162, ARROW #QST-2	EA	4	3	5	4	0.86	5151	20.60
03 046 0125	SWITCH, TUMBLER, DOUBLE POLE, INTERCHANGEABLE QUIETTE, 15 AMP, 120-277 VOLT, IVORY, HUBBELL #1162-I, ARROW #QST-2-I	EA	4	3	5	0	0.00	3.640	14.56
03 046 0127	SWITCH, TUMBLER, 'QUIETTE' TYPE, SINGLE POLE, BROWN, 15 AMP, 125-277 VOLT, AC ONLY, A-H #1891	EA	57	45	90	107	1.62	3.434	195.73
03 046 0129	SWITCH, TUMBLER, 'QUIETTE' TYPE, SINGLE POLE, IVORY, 20 AMP, 125-277 VOLT, AC ONLY, A-H #1991-I	EA	43	30	60	235	4.36	6.097	262.17
03 046 0131	SWITCH, TUMBLER, 'QUIETTE' TYPE, THREE WAY, 20 AMP, 120-277 VOLT, AC ONLY, BROWN, ARROW #1993, HUBBELL #1223, LEVITON #5523	EA	14	10	20	31	1.46	5.857	81.99

03 046 0133	SWITCH, TUMBLER, 'QUIETTE' THREE WAY, 20 AMP, 120-277 VOLT, AC ONLY, ARROW #1993-I, HUBBELL #1223-I, LEVITON #5523-I, IVORY	EA	11	10	20	40	2.87	4.061	44.67
03 047 0001	TAPE, FILAMENT, ¾" x 60"	ROLL	17	12	24	73	4.59	2.828	48.07
03 047 0006	TAPE, FRICTION, ¾" x 60"	ROLL	39	20	50	49	1.40	.889	34.67
03 047 0013	TAPE, ELECTRICAL SEMI-CONDUCTING EPR, SCOTCH 13, ¾" x 15'/ROLL	EA	47	10	20	9	0.39	2.942	138.27
03 047 0014	TAPE, ELECTRICAL SHIELDING BRAID, ALL METAL, OPEN WEAVE, SCOTCH #24, 1" x 15'/ROLL	EA	25	10	20	21	1.22	5.702	142.55
03 047 0015	TAPE, ELECTRICAL GROUNDING BRAID, FLAT TINNED-COPPER, SCOTCH #25, 1" x 15'/ROLL	EA	4	3	5	2	0.42	23.373	93.49
03 047 0016	TAPE, PLASTIC, ELECTRICIAN, #33	ROLL	334	175	350	547	2.35	1.372	458.24
03 047 0018	TAPE, 3M SCOTCH 23 ELECTRICAL TAPE, HIGH VOLTAGE	ROLL	121	80	170	237	2.43	3.692	446.73
03 047 0020	TAPE, CABLE PREPARATION KIT, SCOTCH #A-2	EA	11	5	10	16	1.38	4.265	46.91
03 047 023	TAPE, UNDERGROUND LINE IDENTIFICATION (BRADY #UT20-Y3, 3" WIDTH, 1056 FOOT LENGTH, YELLOW, NAED 63012	ROLL	6	1	6	8	2.34	29.485	176.91

items were charged. If the stores system is part of a larger program, these entries can instantly shift to the job-cost file, or the equipment record file, or other appropriate computer file.

If the stores system is a stand-alone system, it should be programmed to produce a Materials Issued Report for each work order number or account number, at appropriate intervals. Figure 5-2 is a typical Materials Issued Report. The first column is the work order number to which all of the materials are to be charged. The second column lists the various stores requisitions that were used to collect and record the transactions. This is followed by columns showing the dates of issue, stock numbers, descriptions, quantities, units of measure, unit costs, and total cost for each item. At the end of the report the entire cost is summarized. These reports are sent to the accounting office where they are posted to the job-cost files.

Physical Inventories

It is a good management practice to make a physical count of some portion of the inventory each day and to reconcile that with the most current stores Inventory Status Report. The stock clerks can do this when they are not busy with other duties. This practice may reveal a computer data error that can be corrected immediately. This helps the stores manager maintain maximum credibility in the inventory records.

At least annually, auditors require a physical inventory. With a computerized system, a statistical sample is acceptable. In such a case, a random sample of stock items is chosen for the count. These items are then counted and compared with the then-current Inventory Status Report. If they reconcile within a prestated percentage of accuracy (say 99.5 percent), the physical inventory is complete. If the actual count does not reconcile to the predetermined percentage, the sample will be enlarged and additional counting will be necessary until the store or subsection of it meets the confidence level required. Upon completion of the physical inventory, differences are adjusted to the actual count.

The perpetual inventory, along with regular checks of portions of the inventory, will increase the accuracy of the computer records and minimize problems during the annual physical inventory.

Control Indexes

The stores manager can gauge the performance of the enterprise by establishing and observing certain indexes. Typical control indexes are—

- The total inventory curve is a running plot, month-to-month or year-to-year, that shows the total number of items in stock, and/or total value of inventory for each subsection or broad category, or total value of the inventory as a whole.

- The number of stock-outs that occur during a certain interval of time.
- The average turnover interval (ATI) for normal maintenance stock is two to six months, while ATI for spare parts is usually six months or longer.

$$\text{ATI} = \frac{\text{Total value of inventory \$ (Annual)}}{\text{Stock issued \$ (Annual)}}$$

5.5 CONCLUSION

The whole is made from the sum of its parts. From the foregoing discussion it is seen that a properly stocked, properly managed maintenance stores system is an essential part of the physical plant maintenance function. It is as essential as the workers themselves. In fact, if the stores system is not properly managed, the workers will be the first to complain. The successful plant administrator will not permit this to occur, since the whole maintenance mission can be no stronger than its weakest element.

Figure 5-2

Materials Issued Report

MATERIALS ISSUED REPORT
02/18/83

PHYSICAL PLANT DIVISION

PAGE- 1
WORK ORDER #000024

FD YR AG W/O ACCT	PROJ ISSUE	DATE	STOCK NO.	DESCRIPTION	QTY	U/M	UNIT COSTS	TOTAL COST $
000024	0970	02/17/83	03 006 0100	Box cover, handy, 2" x 4", blank, Raco #860	1	EA	.169	$.17
000024	0970	02/17/83	03 020 0031	Connector, box, comp, emt, ½"	1	EA	.125	$.13
000024	970	02/17/83	03 006 0001	Box, handy, 2¼" deep, ko's for ½", 3 side, 1 each end, Raco #670	1	EA	.533	$.53
					ISSUE TOTAL			$.83
000024	5402	02/11/83	01 003 0005	General bathroom cleaner, Johnson Envy (12 - 20 oz cans/case) aerosol	1	CAN	.989	$.99
000024	5408	02/14/83	08 019 0045	Supply, anti-fog cleaning solution, Superclear #350AF	3	EA	1.901	$5.70
000024	5477	02/15/83	05 019 0126	Drywall system, #2 sq end bit tips #25OR1	2	EA	.899	$1.80
000024	5492	02/15/83	01 004 0003	Cleaning supply, new rags (remnants) 5 lb bundle (replaces red rags)	1	BNDL	8.496	$8.50
000024	5596	02/17/83	05 033 0003	Nail set, 3/32"	1	EA	1.288	$1.29
000024	5597	02/17/83	05 035 0360	Semi-gloss pastel base (Pittsburgh #20-6 Glidden #4618)	1	GAL	8.482	$8.48
						TOTAL		$27.59

CHAPTER 6

Grounds Maintenance

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6.1 INTRODUCTION

Scope

Impressions and attitudes are shaped by the condition of a campus. The grounds sometimes make a first impression that may determine enrollment or employment, or students, faculty, and staff may form an attitude about the institution over time. As influential as they can be, properly designed and maintained grounds and interior plantings are not necessarily prime areas of concern to administrators who may not consider the long-range impact. This attitude is changing with emphasis being given to the physical condition of the grounds, as well as campus aesthetics.

Unlike most areas of maintenance, grounds are subjected to unpredictable variables. The grounds manager contends with problems of nature and living things, quite unlike a controlled interior environment. Generally, the mission of grounds maintenance is to provide services that maintain, in an acceptable manner, the exterior portion of the campus, excluding buildings. The mission may be expanded to include maintenance of interior plantings and environments.

Organization

Within the above definition, grounds maintenance organizations exist with varying degrees of success. Success is greatly attributed to leadership. It is important to have trained and enthusiastic supervisors and adequate staffing to achieve the grounds maintenance mission.

The responsibilities of grounds managers vary from campus to campus, depending on the organization's history and the leader's abilities. Often Grounds Maintenance Divisions are charged with additional responsibilities not directly related to traditional services but which utilize labor more economically. For example, moving crews might be assigned to grounds maintenance because of the availability of heavy equipment, the relationship of special events to outdoor programs, or for the use of labor during poor weather conditions.

Another responsibility might be vehicles and equipment maintenance. On most campuses, a high percentage of vehicles and off-road equipment is assigned to grounds maintenance. Because they have the tools and trained personnel, it makes sense that their mission include maintenance of their own and other division's vehicles and equipment. This is especially true in climates that require emergency vehicles to be well maintained at all times.

Grounds maintenance groups generally contain certain units or areas of responsibility:

A Design/Build Group may include landscape architects, horticulturists, surveyors, civil engineers, or other grounds specialists. In some cases, this group is aligned under an office of design (university architect or engineer).

The Landscape Maintenance group is responsible for installing and maintaining plant materials. Groundskeepers, chemical application specialists, arborists, equipment operators, turf specialists, plant materials specialists are integral to this group. A chemical applicator's license or registration is required by most states for at least one person responsible for this operation.

Campus Services is a catchall section with various assignments that include maintenance of pavements (walks, streets, parking lots, tennis courts, and other athletic surfaces), masonry repairs, sewers, and heavy equipment services. Moving and special events crews are easily assigned here.

Refuse Disposal is an area that ranges from total in-house service to completely contracted services. Building-by-building refuse collection, special disposal, collection of material not included as normal building refuse, litter container services, and in some cases hazardous materials handling is included. Some campuses are responsible for transfer stations and other transportation to land fills or trash burning power plants.

If this group is responsible for hazardous materials handling, then employees must be trained with special equipment, vehicles, and knowledge to handle these problems. This operation should be part of a safety division or a separate hazardous materials division with environmental health specialists and faculty representatives in charge.

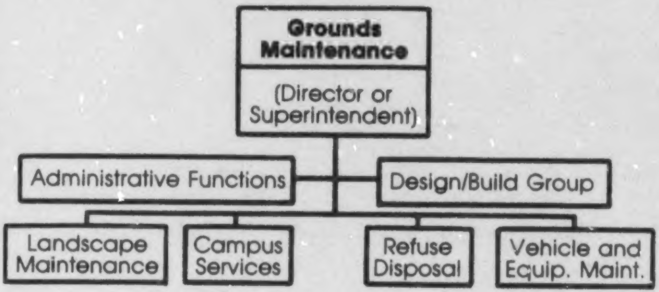
The Vehicle and Equipment Maintenance section is equipped to maintain all vehicles and special equipment used in all campus service operations. Usually, it contains auto mechanics, equipment operators, in some cases laborers, and other equipment maintenance specialists.

An Administrative Function is responsible for the administrative operations of the entire group. This section keeps records, takes orders, and writes requisitions.

The above responsibilities may be combined in various ways depending on the size of the institution. Larger institutions may separate units under a Grounds Maintenance Division that coordinates the overall effort.

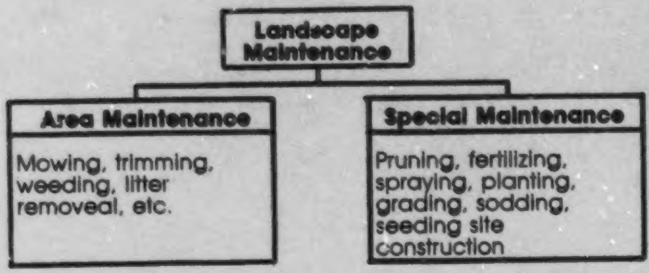
Since variations in organizational structures are infinite, the following chart illustrates a hypothetical organization. This chart identifies separate areas under ideal conditions. From this, various combinations of responsibilities may actually occur depending on campus size.

Figure 6-1


Grounds Maintenance
(Director or Superintendent)
Administrative Functions
Design/Build Group
Landscape Maintenance
Campus Services
Refuse Disposal
Vehicle and Equip. Maint.

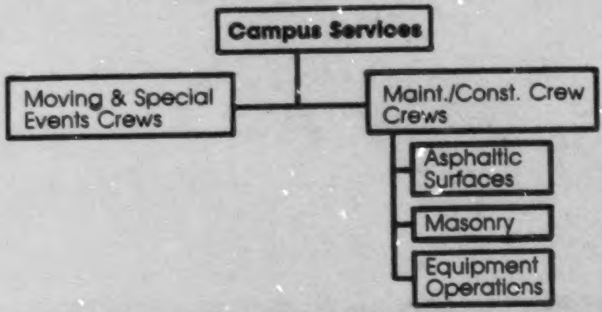
Organizational charts for the separate areas are suggested. The size of the institution determines the combination of responsibilities.

Figure 6-2


Landscape Maintenance
Area Maintenance
Mowing, trimming, weeding, litter removeal, etc.
Special Maintenance
Pruning, fertilizing, spraying, planting, grading, sodding, seeding site construction

Note: All sections are responsible for snow removal from sidewalks and handicap ramps.

Figure 6-3


Campus Services
Moving & Special Events Crews
Maint./Const. Crew Crews
Asphaltic Surfaces
Masonry
Equipment Operations

Note: 1. Moving and Special Events Crew might be created from other Landscape or Construction Crews.

2. Construction crews are responsible for street and parking lot snow removal.

Figure 6-4

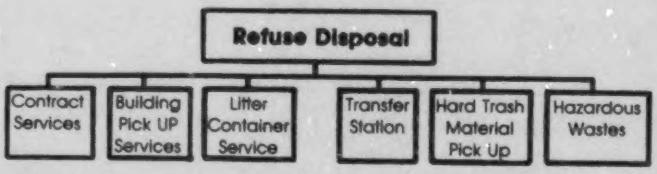
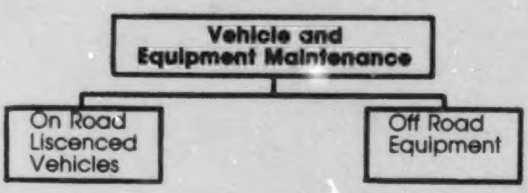

Refuse Disposal
Contract Services
Building Pick UP Services
Litter Container Service
Transfer Station
Hard Trash Material Pick Up
Hazardous Wastes

Figure 6-5


Vehicle and Equipment Maintenance
On Road Liscenced Vehicles
Off Road Equipment

6.2 PLANNING AND SCHEDULING

Grounds Inventory and Maintenance Levels

Every campus has priorities assigned to various spaces. These priorities are established by accumulating information from many sources. There are the important areas such as administration buildings, major entrances, and intensely used areas. High priority is given spaces that require special attention—such as special research areas. Priorities assigned range from informal mental notes to completely recorded and computerized programs.

On some campuses, grounds maintenance programs are not coordinated with the general maintenance function. Coordination occurs only when emergencies require it. Organized programs should be devised to record priorities of maintenance.

The word *priorities* has several meanings. In the eyes of a chief administrator, the aesthetic character of the space around a building or on the route he or she travels may be a priority. To a civil engineer a systematic schedule for street and bridge repairs is a priority. The budgeting process does much to establish the order and length of the priority list. Available funds may require retrenchments accompanied by unpopular decisions. In order to continue essential services and actual high priority maintenance, some priority items may change. When funding levels are restricted, activities with formerly high priorities may become frills.

The balance of prioritized items should be based on (1) critical demands, (2) continuing or preventive maintenance, and (3) administrative mandates. Obviously, administrative directives will sometimes be critical and emergency in nature.

Scheduling

Ideally every item within the boundaries of the campus would be scheduled for maintenance and no emergency situations would occur. Obviously, this is impossible. However, it is not impossible to program items already done on a set schedule. Computer programs that schedule certain types of street maintenance, catch basin cleaning, plant materials spray programs, etc., are used at many institutions.

There are dozens of separate chemical application schedules for treating insects and diseases on lawns, shrubs, and trees. Listing these on a preventive maintenance program reminds the landscape maintenance supervisor to purchase materials, get special equipment ready, and schedule the operation—all at the proper time.

Some types of plant materials maintenance programs, such as mowing and pruning, are difficult to predict due to weather conditions. These items can be scheduled, but are certain to vary. In irrigated areas timing is fairly predictable.

A computerized inventory of all plant materials on campus is especially helpful. Location by grid coordinates, date of planting, complete identification, and special conditions for maintenance are part of this system.

Repetitive Scheduling

Repeated maintenance of specific items varies. Activities repeated daily or weekly, such as litter control, mowing, and street sweeping may not need a system to remind the operators to perform the function. Activities that occur less frequently should be marked on a schedule calendar or included in a computerized system. The more often work is repeated, the more accurate time and cost estimates will be.

While fairly accurate time estimates can be made for mowing even extensive grounds, there is still variation due to weather conditions. Growth rates may cause slower mowing and a significant increase in labor hours. This occurs when growth, including weeds, is heavy, which places pressure on the remaining hours available for other projects. The time required to pick up litter before mowing fluctuates depending on the season, events, academic calendar, and weather.

6.3 EQUIPMENT

With labor costs rising, the proper equipment selection and use are extremely important. Labor reduction for maintenance processes can be dramatic, as well as other operating cost reductions. Supervisors of various maintenance areas should visit institutions with similar problems in order to compare methods and equipment selection.

In addition to selecting proper equipment, regular maintenance and timely replacement are equally important. Poorly maintained equipment causes delays that may even create emergency conditions. The same problem exists if equipment is worn and undependable.

Budgeting for equipment expenditures is considerably easier if a replacement schedule is followed. This schedule is somewhat variable, but will result in costs being planned. The schedule recognizes the limited life of equipment. At the end of its useful life, equipment is replaced from funds held in the reserve. Budget planning administrators see the value of this method, because future funding is predetermined and problem funding is recognized in advance. If possible, replacement schedules and equipment reserves should be entered on a computer program. Items in such a program include department or section account numbers, serial numbers of the equipment, date and cost of original purchase, estimated cost of replacement equipment, amount of dollars set aside each year, amount available in reserve at any given date, and the projected date of replacement.

Leasing certain types of equipment may be more economical than purchasing. Some companies lease to educational facilities at a rate less than the commercial leasing rate. Considering the cost of capital investment, the outlay of funds is minimal if the lease percentage rate is not too high. Equipment is usually leased on a two- or three-year contract, which keeps relatively new equipment in use at all times. This, in turn, reduces the maintenance costs associated with older equipment. Leasing is useful for large or special-use equipment or a series of equipment from one company. Leasing tractors and their allied equipment would include backhoes, snow blades, mowers, augers, etc.

Certain types of equipment have inherent safety problems that should be noted when purchased and during operation. Most equipment with safety problems is delivered with shields, dead-man switches, and other devices. Periodically check to see if these devices are in place and working properly. Some of the more obvious ones that are misused are shields around power takeoff shafts, stone guards on mowers, roll bars, and dead-man switches on riding rotary mowers.

As fuel resources change conversion to diesel engines may be valuable. If this change does occur, extra care must be taken to keep gasoline and diesel fuels separated. Expensive mistakes are easily made. The advantages of diesel equipment include longer hours of operation without refueling, and fewer engine problems.

While keeping gasoline and diesel fuels separate, it is also important to designate mixed fuels for two-cycle engines. Two-cycle engines on smaller mowers are particularly useful on steep slopes and for ease of maintenance.

Campus size, geographical location, labor availability, and weather variations influence the selection of equipment. Contract maintenance also causes differences. Some institutions contract all tree work, others perform it in-house. Thus, needs vary for equipment such as chippers, aerial ladders or cherry pickers, special trucks to handle debris, personal climbing equipment, chain saws, etc.

6.4 GRASS AND TURF

Plant administrators need to remember three principles of turf management.

First, no lawn is stable. It is either improving or declining in quality. Even when a lawn appears to be in good condition, there may be hidden problems beginning to occur.

Second, with proper moisture and fertilization a lawn will be established, weeds will be crowded out, and grasses will grow abundantly. This does not preclude invasion by fungi and insects.

Third, grass will not continue to grow in dense shade. Beware of all the miracle advertisements. There are varieties of grasses that tolerate varying degrees of shade, but none can tolerate shade caused by dense trees. Some of the problems of the dry soil/shade combination are caused by trees absorbing much of the water.

Beware also of growth retardants. Growth retardants are not for everyone. If a salesperson has the answer to all the budget problems, look again. Inhibitors do work in certain conditions. But the chemical to resolve all problems, and at the same time slow down growth, has not been discovered.

Non-irrigated lawns usually experience a dormant period from mid- to late-summer if rainfall is below levels necessary to sustain growth. This is normal, and the brown-blue grass will turn green with sufficient water.

Seed Selection

Consult with a turf specialist or agronomist for seed selection in any given location. As a result of research on turf grass varieties, new selections regularly come on the market. Selection of a combination of grasses suitable for a specific use must be made individually.

Many factors determine selection and include use of the lawn, mowing heights, available water and fertility rates, insect and fungus resistance, shade percentage and intensity, soil factors, and drainage. No common seed mixture is probably just right, and no two turf consultants will prescribe the same solution.

Preparation and Planting

Proper preparation for a new lawn assures the desired end result. In new construction, the site is usually in poor condition for the establishment of turf. All kinds of problems have to be corrected. Sheets of plywood are hidden just below the surface, large concrete chunks are imbedded in the soil, buried plaster or lime causes unknown alkalinity problems. Grounds managers must inspect the construction site or unknown problems will arise for years.

During the grading process, the most important problem is drainage. No turf area should slope less than 1 percent—a bare minimum. Pockets of undrained turf will result in a multitude of problems.

Areas compacted by heavy equipment should be loosened or turf establishment will be difficult until the soil loosens naturally, which can take several years. The entire site should be tilled and evenly shaped. It is not necessary to pulverize the soil completely and it is even better if small lumps creating voids of up to one inch remain.

A fertilizer chosen for the specific soil condition should be applied and worked into the surface. Soil analysis is helpful. but an experienced turf manager will know the requirements of a given site based on other lawns in the area.

Several methods of seeding can be used depending on the site. In small areas seed might be distributed by hand-carried or wheeled rotary seeders. For larger spaces, a slicing seeder or drill might be used, and large areas or steep slopes may require hydra seeding. The latter method can incorporate fertilizer, seed, and mulch in one operation.

Mulch is of utmost importance in the seeding process. It provides protection from erosion, retains moisture, and shades the seed bed. Without mulch, the chances of establishing a lawn are greatly reduced.

Maintenance Problems

As stated earlier, there are a profusion of disease and insect problems in lawns. As the density of a lawn increases, so do problems. The selection of grass for disease resistance is important, and a program of seasonal treatment should be established to cope with standard problems.

One of the common problems of good lawns is the accumulation of thatch. Grass clippings and other miscellaneous particles that build up on the soil surface do not decompose rapidly. This causes a roof effect and reduces the chances of air and water reaching the roots of the grass plants. It also creates an environment conducive to insect and fungus disease growth.

If this layer of thatch gets too thick, it must be removed or a poor turf with all types of decline will be evident. Chemical dethatchers have been introduced, but none have proven successful. Mechanical removal is the only answer, and the lawn must start over. Aeration and slicing will reduce thatch and extend the time between renovations. Annual aeration of heavy-use areas will reduce compaction and allow moisture to permeate the surface.

Mowing schedules and heights must be regulated. In campus situations, particularly where budgets and manpower are limited, mowing gets behind schedule. Heavy windrows of clippings can create fungus problems. Delayed mowing will also injure the grass plant by allowing the leaf to be cut severely into the "white" area. The optimum is to cut more often and remove less grass per cutting. As summer passes, the cutting height should be raised to allow more leaf surface to remain. Short cutting heights are harmful to turf health and sometimes cause the plants to die. This also depends on grass variety. Some varieties withstand short cutting better than others.

If properly graded and drained, most lawns can become acceptable if management establishes a systematic program of chemical treatment, fertilization, and irrigation. Each area of the country requires specific programs. If followed, the lawn quality will improve.

6.5 PLANT MATERIALS

Maintenance problems of plant materials—trees, shrubs, ground covers, and vines—are directly related to the initial selection of the specific plant. If improperly chosen, a plant will be a problem in various ways throughout its life. Many factors must be considered in order to be sure the proper plant is chosen for a specific location.

The one problem commonly overlooked is space. Many times the plant selected will grow considerably larger than the space allows. This causes continual pruning and finally replacement. A common error of designers is to use several plants—causing overcrowding—where one will do the job.

Poor selection may require continuous treatment to condition the soil acidity, or a plant may be chosen that will not withstand wet conditions or areas of poor drainage. Selecting plants that are not hardy enough for a geographical zone or exposing certain plants to sun, snow, or strong winds can be disastrous to certain species.

Soil conditions determine future maintenance problems as much as any one factor. Selection of plants to withstand the various conditions is critical. In urban settings, more and more plants are harmed by air pollutants. This fairly new problem in some areas must be considered.

The person selecting plants for use on campus must understand these common problems. Occasionally, a landscape architect or other designer who practices in a different environment and has no firsthand knowledge of special conditions affecting plants on a specific project is selected to create a planting for a given site. The designer will probably use plant lists for the zone intended, but local conditions may be entirely different. Therefore, consultants must be completely familiar with the area and its problems.

Planting

There are several steps in the planting procedure that frequently cause problems. Preparation of the hole is important. In clay soils, the plant will drown if the hole is too deep and the plant cannot drain properly. If the soil is heavy clay and in a low area or confined (as in a parking lot with curbs), a drainage system must be installed. Trees planted in heavy soils with poor drainage die from too much water rather than from a lack of water. When the hole is dug, it should be no deeper than the depth of the ball to plant at the original level. This keeps the plant from settling out of plumb or to a level that will not drain. The hole should be wider than the ball and backfilled with top soil combined with generous amounts of soil conditioner (peat moss, sand, chips, etc.).

The volume of branches and top must be reduced enough to compensate for root loss in digging. The person handling the plant should not lift the plant by the top, which would break or loosen the ball, and the planted tree must be staked properly. Staking reduces losses due to wind, people, and other physical problems. If staked and mulched properly, the base of the tree will also be protected from mower damage. The twine or cord used in securing the ball must be completely loosened and cut away from the trunk. If not, the tree will be girdled and die. This is particularly true when nondegradable twine is used.

Methods of planting should follow the standards set by the American Association of Nurserymen. Their standards also provide guidance for quality and size when purchasing plant material.[1]

Plant Materials Maintenance

All plants require maintenance in varying degrees. There are no plants entirely free of problems their entire lives. Problems must be dealt with individually, since there are thousands of cultivated plants, each with its own requirements.

Maintenance common to all plants includes watering, fertilization, chemical treatment for proliferation of pests and diseases, pruning, and eventual removal.

Determining proper moisture level for the numerous varieties of plants is difficult. Most plants should be thoroughly soaked and allowed to drain to the point of being dry before being watered again. Most plants will drown if over-watered, but drought conditions can also be damaging. Proper balance can only be reached by learning the peculiarities of individual plants.

Most plants used in cultivated conditions require fertilization. Intensity of fertilization varies according to individual plant requirements. Turf grass plants that are irrigated on well-drained soils require fertilization several times each year. At the other end of the spectrum, a good shade tree in natural conditions requires fertilization on a limited basis. Related to fertilization is the introduction of various trace elements lacking or trapped in the soil. This again relates to improper plant selection. For example, chlorosis (abnormally yellow color) in several varieties of trees is common, and must be treated. Chlorosis results from a lack of iron in a plant. Iron is either not present in the soil or is not available to the plant because of some other soil condition. One of the most common causes is an alkalinity and iron-deficiency combination. The same plants *located* properly will not develop chlorosis.

The various chemical treatment procedures are so numerous that only descriptions of common operations are presented.

- Target Pest. The insect or other organism must be identified before proper treatment can be selected. Identification includes timing, resistance, life cycles, etc.
- Toxicity. Pesticide application will become a subject of public concern if not observed properly. Levels of toxicity are indicated by an LD_{50} value. This is the amount of pesticide that is lethal to 50 percent of a test population in a single dose. It is registered in milligrams per kilogram of body weight and is shown both as dermal and oral indicators. This rating does not indicate hazard, rather the killing ability of a chemical. A chemical can be highly toxic but have little hazard potential because of the way it is used (or misused) and the way it is formulated. The lower the number, the higher the risk factor

due to less volume of material required to be lethal. LD_{50} is not the only way of determining toxicity, but it is a good indicator.

- Phytotoxicity. This describes the effects a selected chemical will have on various, non-targeted plants. Incorrect selection and application methods will result in damage to other plants. An example is 2,4-D injury to shrubs and trees when applied improperly to lawns for broadleaf weeds.
- Compatibility. Certain chemicals can be combined to resolve combinations of problems. There are many chemicals that should not be mixed or will not mix for many reasons. Awareness of this condition will avoid many problems.

Other factors to consider when selecting a specific chemical are its effectiveness, residual behavior, method of application, and employees' capabilities to handle application problems.

Shop rules for safety and procedural methods must be established. Reference publications are available suggesting methods of transportation and storage of chemicals, types of protective devices and clothing, and calibration. Information is also available about other use factors of equipment, personal hygiene, and—with today's emphasis on environmental protection—methods of disposal. College and university agencies, such as agriculture schools and health services, state extension services and manufacturers are all sources of safety procedures.

The problem of safety due to exposure to agricultural chemicals, and the hazards of absorption into the body, cannot be overemphasized. Health testing procedures are available for use in protecting employees and, in turn, the institution. Chemical absorption can result in absenteeism and serious health problems to employees. A good system of detection can benefit employees, and possibly avoid future legal entanglements if hazards are discovered and treated properly.[2]

Pruning One of the misunderstood maintenance procedures is pruning. The word *pruning* cannot be substituted for *shearing*. The quickest way to ruin plants and the original intent of a plant selection is to allow them to be sheared into round balls or flat-topped cones, unless a formal garden is intended. The use of the hedge clippers can injure plants and ruin the plants' intended purpose.

Pruning should be done to remove dead or damaged branches, retain original plant shape, control the size of the plant, or for renewal purposes. Pruning should be performed by trained personnel at specific times of the year as needed by the type of plant. On larger campuses, or where labor is a problem, pruning can be done almost any time. Some sacrifices must be made—such as loss of flower or fruit the following season.

Disease control is an important reason for pruning. Some infected plants or groups of plants can be spared the spread of disease if infected branches are removed and destroyed. In some cases, the pruning equipment must be sterilized after each cut to keep from carrying the infection from plant to plant. Dipping tools in alcohol is effective.

Ivy The maintenance problems associated with ivy-covered walls involves potential damage to masonry and wood moldings.

The two most common ivy plants covering the walls of many buildings are either the deciduous plant, *Parthenocissus tricuspidata*, commonly called Boston Ivy, or the vine that does not lose its leaves, *Hedera helix*, English Ivy. Each has its advantages and disadvantages.

Boston Ivy grows rapidly, sometimes as much as 10 feet a year. When it loses its leaves each fall, it acts like most deciduous plant material and displays fall colors of bright orange, red, and crimson. Boston Ivy climbs readily on nearly any surface by using adhesive discs at the tips of its tendrils. These tendrils do not seek cracks or crevices but adhere to the surface. The vine should not be allowed to grow unrestrained behind and between moldings, joints, or on wood surfaces.

English Ivy, a dark green-leafed vine, is a much slower growing plant and, in some conditions, not nearly as hardy as Boston Ivy. In certain locations, it will freeze back to the ground and must be removed. In the proper location it is an excellent plant as a ground cover or grown vertically on walls. Some smoother surfaces do not have enough texture to support English Ivy.

Both vines provide shading of walls and insulation against bright sunshine. Ivy's value as insulation has not been determined but is significant.

The added aesthetic values probably outweigh the negative attitudes, costs to control growth, and potential damage.

6.6 INDOOR AND TROPICAL PLANTS

Interest in indoor plants has risen dramatically over the past ten years. Although the idea of growing plants inside is not new, it has never been so popular. Now tropical foliage plants in building interiors have become as necessary as they are fashionable. Plants not only beautify our surroundings, but create an atmosphere of warmth and life. Most importantly, office plants provide a comfortable environment that improves worker morale and efficiency.

There are various architectural uses for plants. Architects and designers include interior foliage plants in their plans as a standard practice for several reasons. Plants can be used as a visual screen and to diffuse sound in open-plan space designs; to help soften hard lines or surfaces and add texture to nondescript surfaces; to give people directional clues; and to complement furnishings with color, texture, size, and shape.

Plant Selection

In choosing plants for interior landscaping, or plantscaping, there are three considerations that are of primary importance: location, type of plant, and size of plant. Location determines which types of plants can be used most satisfactorily and the size suitable for the particular surroundings.

Since indoor conditions are usually not conducive to vigorous plant growth, plants that are already the desired size, or slightly smaller, should be chosen. Indoor plants rarely outgrow their allotted space. Above all, select healthy insect-free foliage. A poor quality plant has less chance of thriving indoors than does a hardy, high quality plant.

Location

Foliage plants most often found in campus buildings are placed in public areas such as entrances, hallways, lobbies, and lounges. Budgetary limitations often do not allow for plant decoration in private offices. Foliage can be used to personalize a desk, fill the space on top of file cabinets, or create height variation among one-level office furniture.

Light intensity and duration are crucial to plant health. Therefore, it is important to place plants near the light source. The brighter the light provided, the shorter the period of illumination required. Most plants require 12 to 16 hours of artificial light a day, if that light is between 200 and 500 footcandles. (A footcandle is one lumen of light projected on one square foot of area.)

Sunlight is the most desirable kind of light, but may be unavailable. If artificial light is the sole source, fluorescent is better than incandescent. Fluorescent light produces darker green foliage and more compact growth. Plants grown in incandescent light have a tendency to become weak and spindly.

Insufficient light results in loss of lower leaves, weak stems, pale coloring, and eventual death of the plant. Too much direct sunlight scorches foliage if adequate ventilation is not provided to reduce heat buildup next to windows.

Temperature and Humidity Control

Foliage plants require moderation in both temperature and humidity. Generally, what is comfortable for people is appropriate for plants. The specific temperature range in which plants thrive is 55° to 80°. Avoid placing plants near drafty doors or windows since these spots may be as much as 20 degrees colder than the rest of the area.

If the heating, ventilation, and air conditioning system removes too much humidity from the air, there are several ways to increase it around the plants. Set plants on trays of moist pebbles, mist leaves frequently, or install a humidifier. Not enough humidity creates symptoms similar to those of underwatering. Leaf tips turn brown, margins yellow, and growth is stunted. Too much humidity over a long period makes plants susceptible to bacterial and fungal invasions. For this reason, misting leaves is not recommended, but can be done if plants are regularly monitored for disease.

Care and Maintenance

To ensure the success of interior plantings, qualified personnel must be provided. Many grounds maintenance departments have employees with education or work experience in ornamental horticulture or floriculture. Depending on specific departmental policy, the horticulture staff may or may not be required to maintain office and other interior plants. For example, the grounds maintenance horticulture staff may purchase and install foliage plants, but policy may not allow this staff to maintain the plants. Office workers where the plants are placed are then responsible for maintenance. In this case, plant care should be assigned to an employee who has an interest in plants. Interested people are more aware of the greenery and will usually provide better care.

In large institutions, it is not feasible to have employees care for plants. Hiring a plant leasing firm is an excellent, though expensive, way to maintain plants. These firms are experienced at maintaining, as well as selecting and installing interior foliage. They can provide the skills needed to lengthen a plant's life indoors, and thus reduce replacement costs. In addition to maintaining existing plants, these companies offer purchase only, purchase/maintenance, and lease/maintenance contracts.

Watering

How a plant grows is determined by the controlled environments of building interiors. Light, temperature, humidity, soil moisture, and nutrients are all interrelated and all affect the strength and health of a plant. Soil moisture is one of the most significant requirements of foliage plants.

Light, temperature, humidity, and soil type determine moisture needs. Common sense tells us that plants use more water when it is hot. Likewise, an increase in light or a decrease in humidity increases the need for water.

Watering should not be a routine practice, such as watering the plants every Friday. By testing the soil with a moisture meter or index finger, one can accurately decide if plants need water. Ninety percent of plant losses are due to improper watering, usually overwatering. Most plants need to be watered when the top one or two inches of soil is dry. Some species need more frequent watering, some less.

When it is time to water, add water from above. Subirrigating can cause root rot by saturating the soil airspaces. Use lukewarm water, especially in the winter, since cold water may damage foliage.

Fertilizers and Insecticides

Plants grown in artificial light require only 10 to 30 percent as much fertilization as those grown in natural light. The less light received, the slower the growth rate; thus, a diminished need for nutrients.

A complete fertilizer, which contains nitrogen, phosphorus, and potassium should be used—preferably one with calcium, magnesium, and iron. Liquid, water soluble, or time-released pellets can be used if they are applied at half-strength. A light feeding every three to six months will do. Too much fertilizer applied too often can result in a salt buildup in the soil. Excess salt causes leaf-tip and margin burn, and root deterioration.

Insect problems account for only 5 percent of plant losses, but their control is the most difficult aspect of plant maintenance. Prior to installation, check the plants closely for signs of insects. If insects are found, treat the plant immediately. (One mealy bug can lay up to 600 eggs.) Use recommended pesticides, and follow label instructions carefully. A highly concentrated solution can severely injure foliage, and a weak solution will be ineffective. If a spray is used, treat three times at weekly intervals in order to kill all the eggs.

Spraying a plant for bugs in public buildings may be a difficult chore. The Environmental Protection Agency only allows the use of Kelthane^R, petroleum oils, and natural pyrethrins in public areas. The odor from Kelthane^R is offensive, and the fumes potentially harmful. Plants should be moved outside, if possible, or to a storage room for spraying.

Cleaning and Pruning

Foliage must be cleaned regularly to keep plants healthy and looking good. A heavy coat of dust clogs the stomata—the cell openings that allow for the exchange of gases and release of moisture. In a greenhouse, plants can be sprayed with one tablespoon of liquid detergent (Dove^{TM} or Ivory^{TM} are best) mixed in one gallon of water to rinse off dust. To remove chemical residues or heavy dust accumulations, use a sponge or soft cloth and carefully clean each leaf. This method is time-consuming, but does the best job. A feather duster can be used on plants already installed and is quick and easy.

Pruning tropical foliage plants can be done to encourage new growth, enhance plant shape, or remove dead or diseased parts. There are two ways to prune—pinching or cutting back.

Pinching of the terminal (end) growing tip is usually done to produce dense, bushy growth. When the growing tip is removed, dormant leaf-producing buds lower down on the stem produce side shoots. This type of pruning is usually done with the thumb nail or scissors. Only a quarter- to a half-inch is removed, just above the leaf node.

Cutting back is done to thicker or harder stems, and requires pruning shears. The cut should be made flush and at the base of the stem, so as not to leave a stub. Pruning flush with the trunk or stem will ensure clean, quick healing wounds. Dust large, fleshy wounds, such as a those on Dieffenbachia, with a fungicide to prevent stem rot.

6.7 MAINTENANCE OF OTHER GROUNDS FACILITIES

Maintenance of paved surfaces, storm drainage systems, site furniture, fountains, signage, fences, and retaining walls is an important part of grounds maintenance. Many of the conditions are common, but geographical location causes dissimilar methods of maintenance.

Paved Surfaces

The types of paved surfaces range from loose gravel to fine hand-laid quarry tile or exposed aggregate surfaces. Each material requires its own method of maintenance, but there are some common practices for each.

Before any material is selected, consideration must be given to its intended use, type of traffic, cost to install, cost to maintain, life expectancy, aesthetic conditions, availability of materials, and weather and seasonal factors.

The most common problem of paved surfaces is the lack of drainage. This is particularly true in climates that expose surfaces to continued freeze-thaw cycles. A soft sub-base caused by wet, poorly drained conditions results in movement, pumping, and other problems. The importance of good drainage cannot be overemphasized.

Problems with concrete pavements can be attributed to specific causes. As with paved surfaces, drainage is important. However, concrete can be of poor quality for several reasons. First are placement problems. Overworking of surfaces or retempering is common and particularly critical in cold climates. When being poured, concrete can easily begin to harden before the finishers have time to work it.

Improper mix or proportion of materials continues to be a problem. Strength and surface spall problems are directly related to misuse of water, as is the retention of water for proper curing. Concrete that is not immediately sealed or properly protected for curing will have surface and strength problems. Poor selection of aggregate and lack of air entrainment will also cause a variety of failure situations.

Budgets for construction projects are sometimes inadequate and many details are reduced in design. Problems result from reductions in design strengths, or sections of pavements. Surface courses may be omitted, or a less effective surface is installed, with later resurfacing intended. Breakdown occurs earlier than "scheduled," and money is not available for improvement or repair.

Storm Drainage

Storm drainage problems are frequently caused by undersized lines and backups. Lines that were adequate at one time become inadequate as more hard surfaces are installed, increasing the speed of runoff. Since the greatest cost of installing storm sewers is for labor and catch basins/manholes, always demand oversizing of the pipe. To increase size or add more lines later is expensive, considering site restoration costs.

On many older campuses, combination storm and sanitary sewers were built. At that time, both types of sewage were either treated or dumped directly into nearby streams. Today this causes overloading of both sanitary and storm systems, as well as being unacceptable and unlawful. Enforcement agencies are demanding that these practices be changed.

Total cleaning and inspection of storm sewer inlets and manholes is frequently overlooked until backups or failures occur and become emergencies. This activity should be included in a preventive maintenance schedule.

Site Furniture

A frequently overlooked problem on many campuses is the lack of adequate refuse containers. Even if there are enough containers, sometimes they are inappropriate for a college or university campus.

This may be true of other outdoor furniture as well. Benches, light poles, and planter boxes should harmonize with their surroundings. The disruption of an otherwise pleasant atmosphere occurs if site furnishings are improper. Selection of a standard is wise and should be followed.

Fountains

Fountains are difficult to maintain. The expenditure of dollars and man-hours required to keep them in running condition is, at times, questionable. The installation of additional water features should be studied with this in mind.

Ongoing maintenance costs of fountains are usually higher than other installations because of student-related activities. Therefore, the location and design can significantly affect maintenance costs.

The complexity of design and mechanical systems will make a considerable difference in maintenance demands. Varying water movement, lighting, and special spray nozzles contribute to increased cost. Regular treatment in warm climates or during the summer is necessary to control algae growth. Occasional emptying is required for cleaning and to remove objects.

Water attractions are pleasant and usually improve aesthetics. Care must be taken in design to be certain maintenance is possible within realistic budgetary restrictions. In all cases, fountains increase costs.

Signage (Exterior Graphics)

The most significant item that can visually clutter a campus is the proliferation of non-standardized signage and exterior graphics. Strong institutional rules should regulate all types of signage: visual graphics, posters, traffic control signage, informational and directional signage. These regulations should stipulate a standard to be followed and place the responsibility and authority for enforcement on one specific division or person.

Bulletin boards and kiosks should be located strategically throughout the campus, and only these should be allowed for posting. Old posters, residue tape, and glue can easily make a campus look shabby.

Building identification, directional and informational signage should all follow a set standard using harmonious colors, locations, sign shapes, and alphabet types. These standards establish an important continuity throughout the campus.

Allowing graffiti to accumulate only encourages more. Materials are available to remove all types of paint and marking materials from various surfaces. As soon as improperly placed posters, signage, and graffiti are discovered, they should be removed. All staff personnel should be trained to participate in this effort. A campus kept clean will stay clear of litter and unwanted graphics.

Fences

Fencing on a campus is sometimes needed to direct traffic. In many cases fencing could be replaced by plants, or pavements could be redesigned to provide proper traffic flow. Extensive use of fencing should be avoided, if possible. Too much fencing may obstruct a view or diminish the aesthetic continuity of space.

The fencing material should be as pleasing and unobtrusive as possible but still do its intended job. A dark plastic coating on chain link fencing helps it recede visually, or a simple pedestrian fence of heavy timber post and chain create a park-like atmosphere.

Avoid temporary-looking fences whenever possible. They usually become permanent and detract from the campus setting. If a temporary fence is constructed using a drive post and wire, ribbon or brightly colored tape must be fastened to the wire to make it more visible. Serious accidents can occur with unmarked wire.

Fencing is another of the many items on campus that, if allowed to depreciate, will create a less-than-satisfactory appearance.

6.8 SNOW REMOVAL

During the winter months, grounds maintenance crews at institutions in northern climates confront one of the toughest problems in their area of responsibility, and one that has terrible public relations consequences if not satisfactorily handled. This is the removal of snow and ice.

In order to answer questions and serve the institution in a methodical way, priorities must be established and a working system implemented. Snow removal problems vary depending on administrative attitude or demand, location, temperature fluctuation, topography, and availability of funds.

Establishing Priorities

Every person on campus believes that his or her department, parking slot, or building should have first priority for snow removal. However, work can only be accomplished by following priorities that may be unpopular.

At institutions with medical centers that provide 24-hour emergency care, the number one priority is obvious. Access from major arterial roads and walks to this service is critical. Student health centers that provide similar emergency care would also have a high priority. Second priority is usually assigned to power plant service areas, residence halls, and food services areas. Then the remaining main roads and walks serving classrooms and research buildings are cleared of snow.

Handicap ramps and curb cuts, a high priority for mobility of a limited number of people, are of no value until the surrounding streets and walks are in passable condition. Therefore, ramps and curb cuts should have the same priority as adjacent surfaces.

Employee Notification

A workable system of mobilization is of prime importance. The responsibility of initial notification rests with a department and specific individuals that are on campus during "non-working" hours. If snow or ice conditions occur during working hours, the removal process can begin as needed. In the evenings, on weekends, and during non-business hours the responsibility of notification must be clearly established. The job is often assigned to campus security since they are on duty 24 hours a day, every day.

Once the person with notification responsibility determines a need—based on established guidelines—he or she should call a supervisor assigned to determine the extent of the emergency. Several people should be on a call-list in case the first person is not available. In some cases, this might be a rotating list to allow the responsibility to be distributed.

The supervisor should immediately come to campus, or, if nearby, determine the level of call out needed under the present conditions. At times only a small crew is needed, but if conditions appear to worsen, then varying degrees of call-outs—up to an all out effort—should be activated.

On large campuses where a call-out list is long, reduce time spent notifying employees by forming groups of lists with fewer names to be called by several people. This also frees the primary supervisor to make other decisions and begin the work process.

The decision to call out employees or contractors is difficult and relies on experience, as well as other readily available information. National and local weather forecast information and contacts with local agencies are important.

Supervisors should not overlook communication with the institution's top administrators if conditions warrant restricted movement or school closing.

Equipment Requirements

A self-sufficient winter maintenance program requires the purchase and use of proper equipment. The *minimum* amount of equipment required is as follows:

- Caterpillar Front-end Loader—Model 930, or equal (Figure 6-6).
- Dump truck(s) equipped with plow (Figure 6-7).
- Sand/salt vehicle (Figure 6-8).
- "Bombardier" snow plow, or equal (Figure 6-9).
- Small snowblower (Figure 6-10).

The Caterpillar 930 is basic to an in-house plowing operation. With its power, maneuverability, and versatility this loader will do the work of three trucks. When plowing is completed, the plow blade is easily removed and replaced with the bucket for loading the mounds of plowed snow into a dump truck to be hauled away. The bucket can also be used for cleaning snow-filled dumpsters, alleyways, and loading dock areas (Figure 6-11).

A sand/salt vehicle, designed specifically for sanding and salting, is essential to a safe and efficient operation. The alternative of mounting a sand/salt unit inside the body of a dump truck has many disadvantages. The dump truck is lost for the entire winter. Spillover causes salt corrosion of the dump truck body. And with the extra height added to the back, the vehicle becomes improperly balanced. This can be especially hazardous in hilly terrain. Improper balance causes swerving on the downgrade, which in turn causes the unit and load to shift, knocking the unit off-square and snapping the tie-offs. A heavily loaded, unbalanced vehicle moving uphill has a tendency to lift off the ground a bit in front.

Figure 6-6

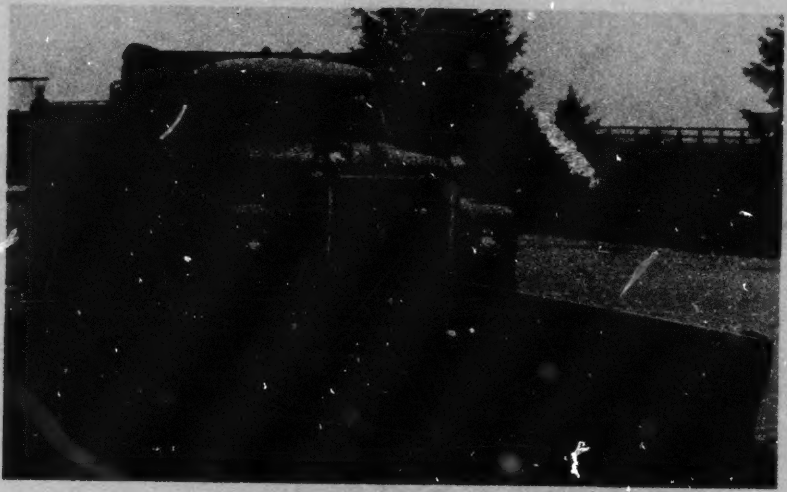


Figure 6-7

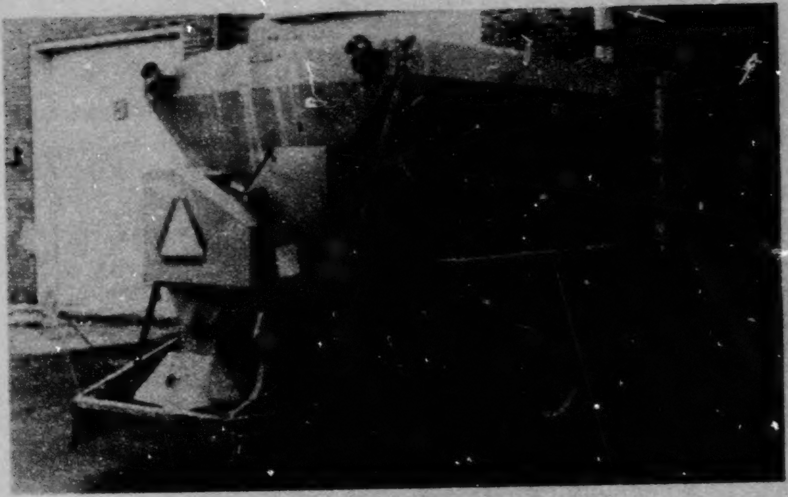


Figure 6-8

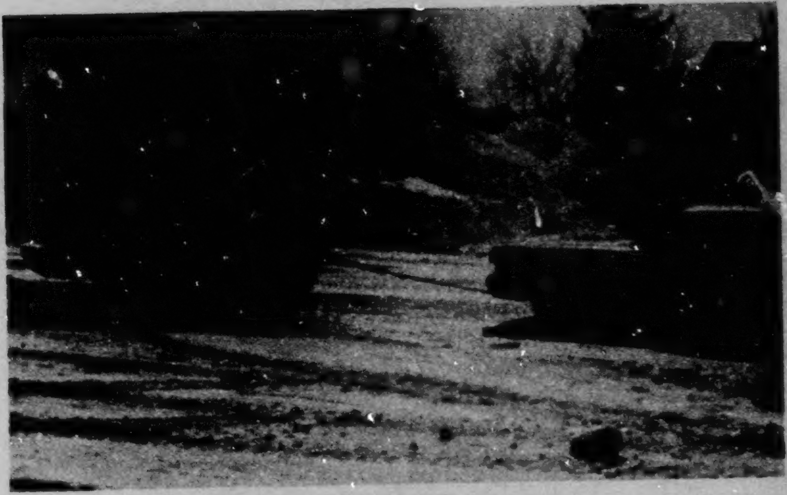


Figure 6-9

Figure 6-10

If the cost of a new sand/salt vehicle places too great a strain on the snow removal budget, there are other alternatives that require some improvising and resourcefulness. The institution may purchase a used diesel truck-tractor. Plant shop personnel can then convert it to a sand/salt vehicle by removing the fifth wheel and mounting the bed and sand/salt spreading unit permanently to the frame. The cost of the converted vehicle will be about 20 percent of the cost of a new vehicle. Military surplus materials, including vehicles, are available to tax-exempt institutions at minimal cost through state and federal agencies.

The Bombardier snow plow has no equal when it comes to clearing sidewalks quickly and efficiently. Its steel cleats effectively break up ice on glazed walkways. The straight blade is sufficient to clear away snow after moderate storms, and the "V" blade will readily go through five feet of snow.

The snowblower is used mainly for clearing flat rooftops after a major storm. It removes only the heaviest part of the snow and leaves two to three inches of snow between the blade and the roof surface. Snowblowers are fine for small areas, or for light, powdery snow. They tend to stall and clog in wet, heavy snow, or if pushed too fast. These characteristics make them unsuitable for long-term sidewalk use.

Snow removal is a taxing grounds maintenance task. Heavy snow and long hours of continuous use create considerable stress, even on heavy and ruggedly designed equipment. The overtime hours required by many snowfalls impose enough pressure on maintenance crews without equipment

Figure 6-11

breakdowns generating additional frustrations. Investing in the best possible equipment for each job pays off in higher morale among the workers and a more efficient and productive operation.

Manpower Requirements

Personnel to form crews for snow emergencies can come from several sources, and duties should be assigned to relate as closely as possible to normal assignments. Custodial employees can remove snow and ice from entrances, steps, and landings. Grounds maintenance people, usually experienced with heavier equipment, should be responsible for snow removal from sidewalks and curb cuts.

Street and parking lot snow removal may be assigned to grounds maintenance crews or to a campus service group that operates heavier equipment and trucks. Equipment maintenance personnel should be on duty to repair breakdowns and install plows. Some institutions supplement their regular maintenance crews with part-time student workers during periods of heavy snowfall.

A strong agreement on participation in emergency call-out procedures should be made with the employees and their labor organizations. Some employees may delay their response to emergency calls, or not respond at all. The established policy should include method of contact, response time expected, payment for overtime or compensatory time granted, and job responsibilities.

In the case of an emergency condition that could last for many hours or days, it is important to phase the working hours of available labor. Repetitive shifts in cold weather should last about 12 hours maximum. Beyond this, efficiency and safety capabilities reduce rapidly.

Just before the first snow or ice conditions are expected, hold a brief meeting of all employees and/or contractors to explain or review the mission and expectations of the operation and delineate responsibilities of the various crews. It is helpful to ask various agencies on campus to send representatives. Interested groups include security, traffic, custodial, handicapped representatives, and general administration. Problem areas can be discussed and special requests or expectations presented.

Instruction and training in the use of equipment and distribution of salt is invaluable. Damage to the campus can be extreme if care is not taken. Plow damage becomes quite obvious as winter snows melt and grass does not grow.

Attention to details can make snow removal a success. Placing stakes at walk intersections to guide operators when the area is entirely covered or providing coffee and hot chocolate for employees during long hours of overtime improve the operations efforts (Figure 6-12).

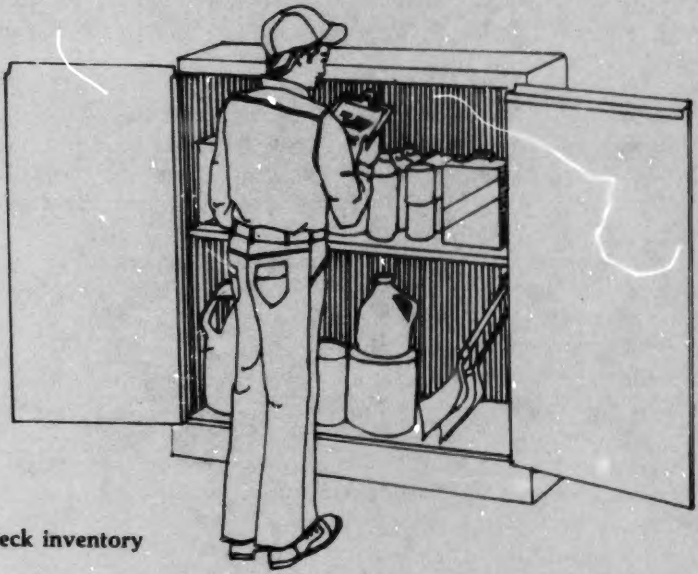
Planning and Methods for Snow Removal

Preparation for winter maintenance and snow removal begins early in the autumn with the development of the following checklists:

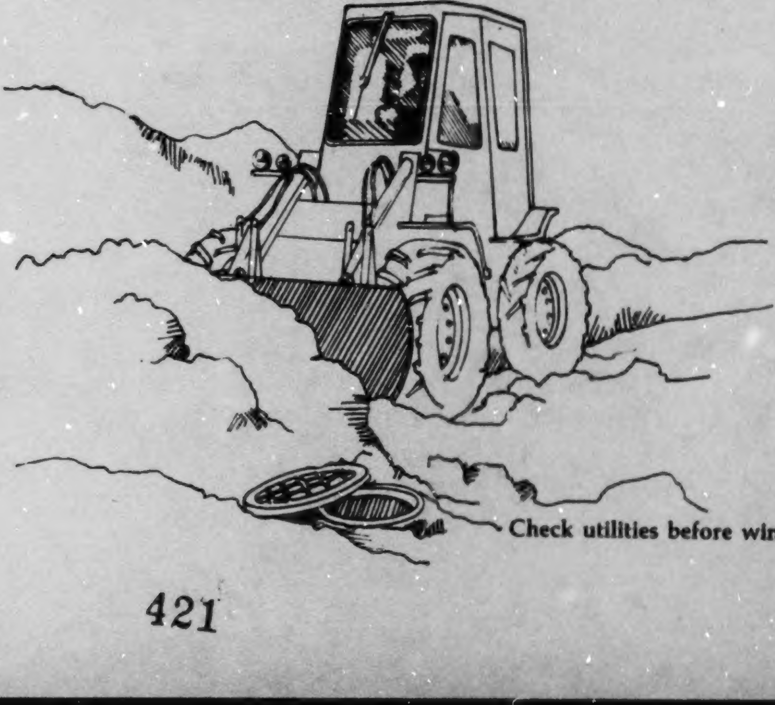
September

- Order hydraulic oil for plows.
- Check supply of truck chains and spare cross links.
- Order fuses, blades, wiper arms, and headlights.
- Grease and oil all vehicles.
- Have all emergency oil tanks for generators filled for winter.

Figure 6-12

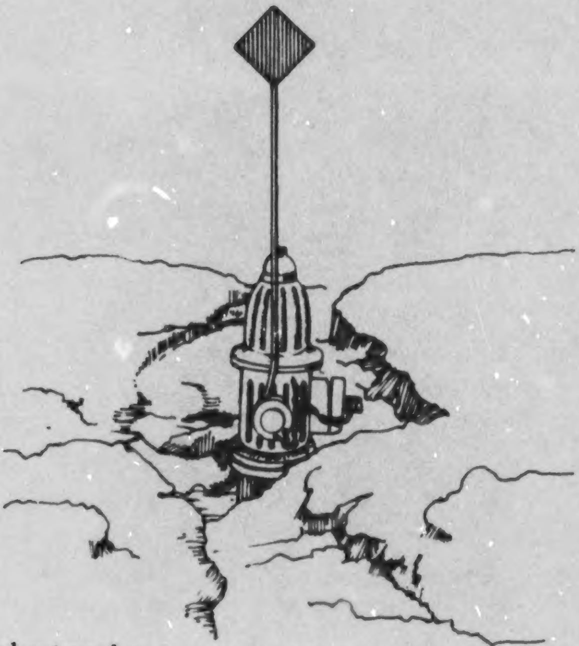


Check inventory

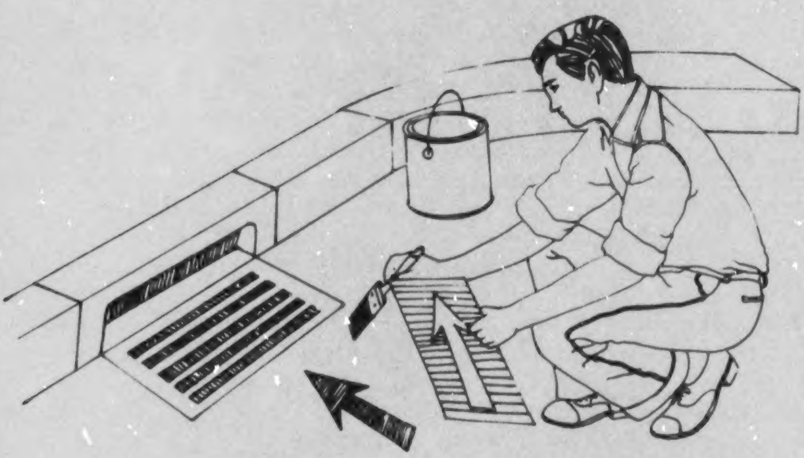


Check utilities before winter

Figure 6-12



Hydrant marker



Mark all drains

- Issue blanket purchase order numbers for bulk sand and salt.
- Order snow shovels and scrapers.
- Order extra plow pins and cotter pins.
- Order ice-melting material for stairs and walks.
- Repaint arrows indicating catch basins.

October

- Put out storm stairs and porches (Figures 6-13 and 6-14).
- Place all hydrant markers.
- Advertise for student shovelers to be placed on call list.

November

- Make walking inspection tour of campus.
- Repair any protruding utilities in roadways.
- Salt and sand should be in storage.
- All supplies should be stocked.
- All equipment should be checked, repaired, and ready for operation.
- Activate Zip-call beeper and schedule standby people.
- Coordinate winter parking regulations with campus security and dean of students.

Storm records, sanding/salting records, and snow removal vehicle records should be kept throughout the snow season. These records are valuable for planning the snow removal activities for the next year. Figures 6-15, 6-16, and 6-17 illustrate typical forms that can be adapted for this purpose.

Clearing roadways and campus parking areas designated for use by commuters normally poses no particular problem. Clearing resident student parking lots, however, is more difficult and requires the coordination and cooperation of the grounds department, campus security, dean of students, and students. Early in the winter the dean begins the procedure by issuing a Snow Emergency Notice that reviews the regulations regarding parked cars and snow removal. Notices should also be placed in all residence halls at least 12 hours before plowing of the parking lots begin. During the winter no parking should be allowed in the visitors' parking lots after midnight.

The plowing procedure begins by clearing the empty commuter lots and opening a driving lane through the resident student lots. Ideally, all students then move their cars to the visitors' parking area. This allows the resident lots to be cleared within two or three hours. For a variety of reasons (dead batteries, no snow tires, out of gas) many of the students' cars are not moved. All student vehicles are registered with the Campus Security Office and have a parking decal. Security can identify the owners and inform them that their cars are parked in an area designated for snow removal and must be moved.

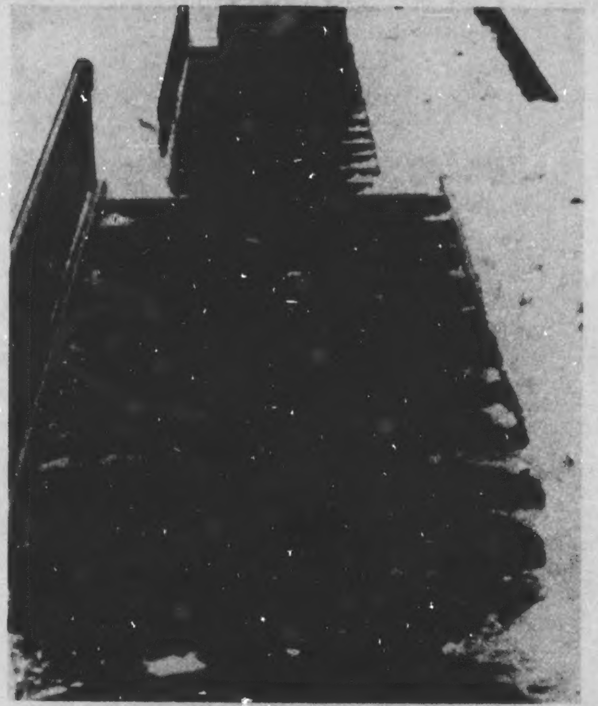


Figure 6-13

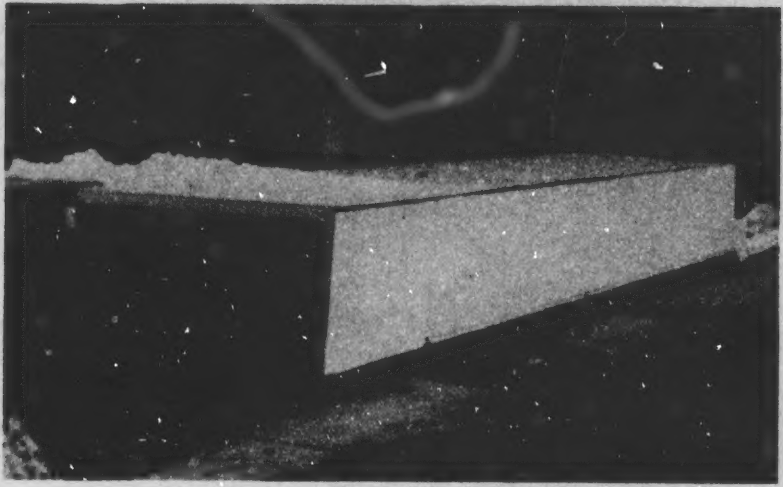


Figure 6-14

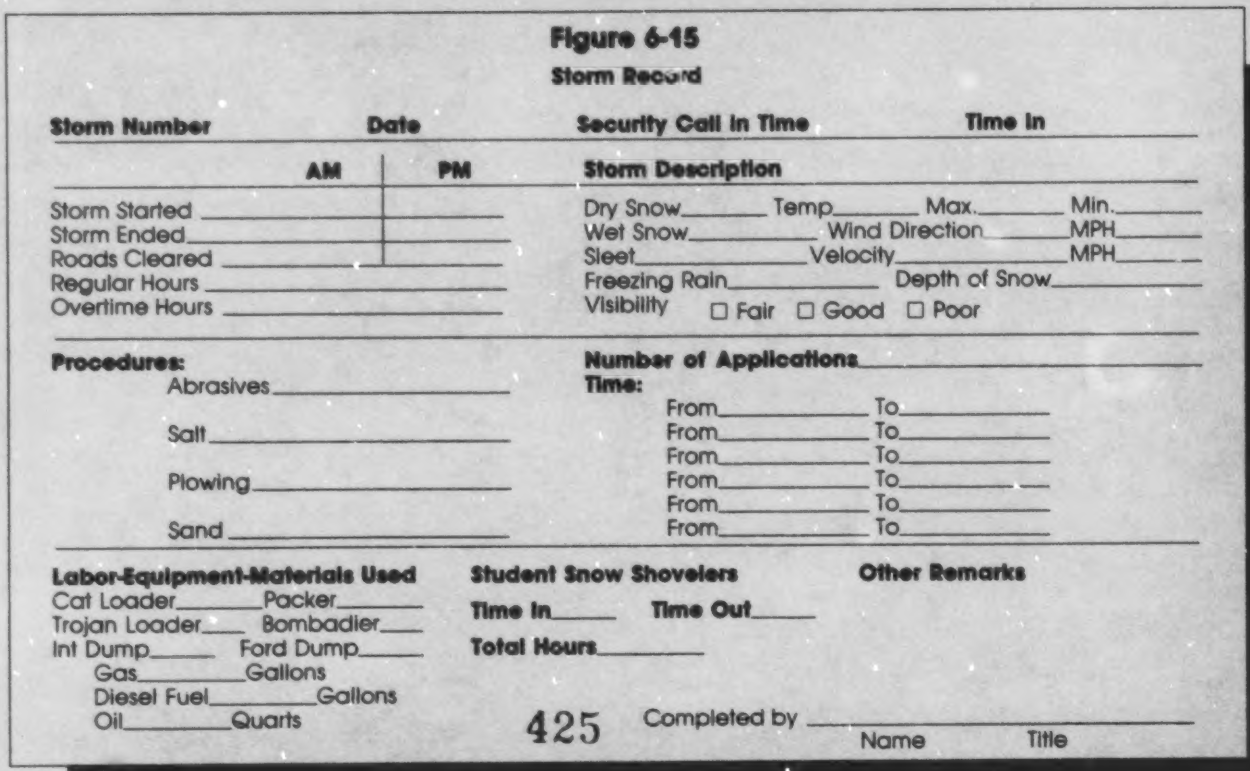


Figure 6-15

Storm Record

Storm Number **Date** **Security Call in Time** **Time In**

	AM	PM
Storm Started		
Storm Ended		
Roads Cleared		

Regular Hours ____

Overtime Hours ____

Storm Description

Dry Snow ____ Temp ____ Max. ____ Min. ____

Wet Snow ____ Wind Direction ____ MPH ____

Sleet ____ Velocity ____ MPH ____

Freezing Rain ____ Depth of Snow ____

Visibility ☐ Fair ☐ Good ☐ Poor

Procedures:

Abrasives ____

Salt ____

Plowing ____

Sand ____

Number of Applications ____

Time:

From ____ To ____

From ____ To ____

From ____ To ____

From ____ To ____

From ____ To ____

From ____ To ____

Labor-Equipment-Materials Used

Cat Loader ____ Packer ____

Trojan Loader ____ Bombadier ____

Int Dump ____ Ford Dump ____

Gas ____ Gallons

Diesel Fuel ____ Gallons

Oil ____ Quarts

Student Snow Shovelers

Time In ____ **Time Out** ____

Total Hours ____

Other Remarks

Completed by ____

Name Title

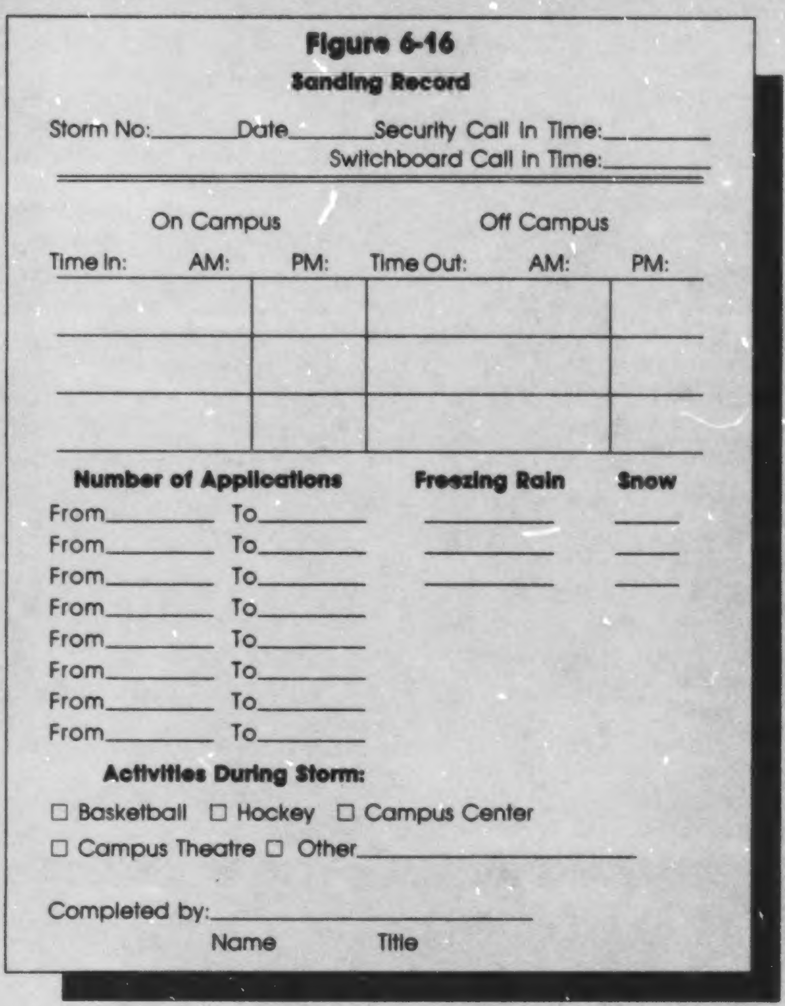


Figure 6-16

Sanding Record

Storm No:________Date________Security Call In Time:__________
Switchboard Call In Time:__________

On Campus			Off Campus		
Time In:	AM:	PM:	Time Out:	AM:	PM:

Number of Applications		**Freezing Rain**	**Snow**
From__________	To__________	____________	______
From__________	To__________	____________	______
From__________	To__________	____________	______
From__________	To__________		
From__________	To__________		
From__________	To__________		
From__________	To__________		
From__________	To__________		

Activities During Storm:

☐ Basketball ☐ Hockey ☐ Campus Center
☐ Campus Theatre ☐ Other__________________________

Completed by:______________________________
Name Title

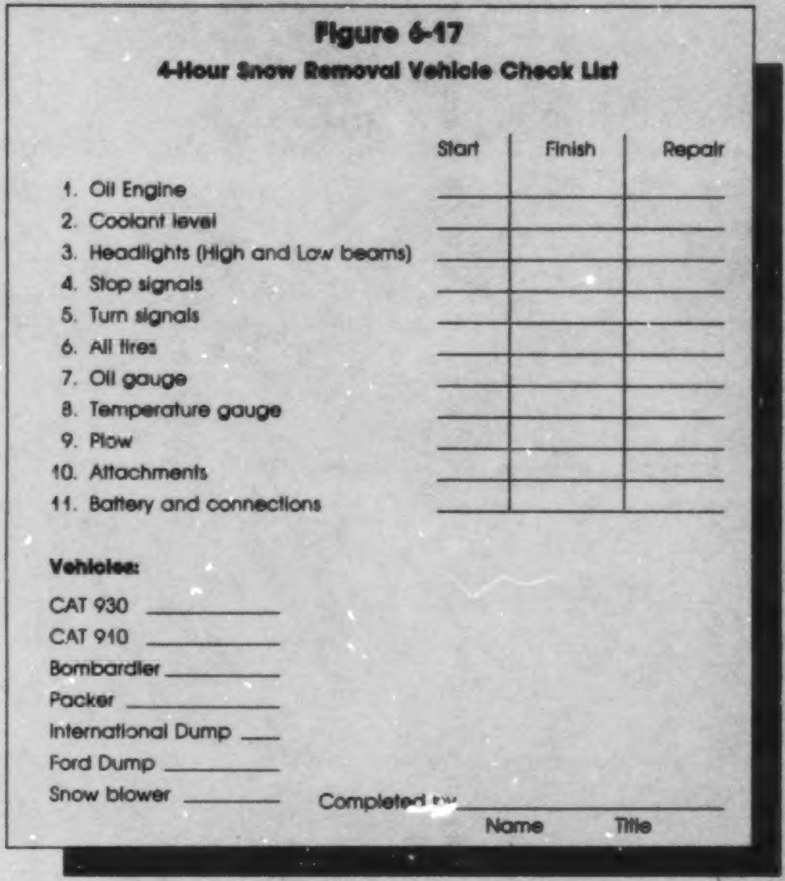


Figure 6-17

4-Hour Snow Removal Vehicle Check List

	Start	Finish	Repair
1. Oil Engine			
2. Coolant level			
3. Headlights (High and Low beams)			
4. Stop signals			
5. Turn signals			
6. All tires			
7. Oil gauge			
8. Temperature gauge			
9. Plow			
10. Attachments			
11. Battery and connections			

Vehicles:

CAT 930 ____________

CAT 910 ____________

Bombardier ____________

Packer ____________

International Dump ____

Ford Dump ____________

Snow blower ________

Completed by ____________________

Name Title

As a last resort cars can be towed to a holding area on campus cleared for this purpose, and the owners required to pay the towing fee in order to retrieve their cars. An on-campus holding area spares the students the expense of paying a daily storage charge and the initial towing fee is lower than if towed to an off-campus holding area.

Student shovelers assist the regular crew and assure the fastest possible clearing of stairways. Advertisements placed in the school newspaper, on the campus radio station, and on residence hall bulletin boards will recruit interested students. Payment in cash the day after the storm is a good idea, provides an added incentive, and ensures a good turnout. A list of neighborhood youths can be drawn upon during vacation periods when resident students are away from campus.

Environmental Considerations

Grounds personnel must maintain an environmental awareness during snow removal operations and control the use and abuse of materials such as de-icing salt. While public safety may demand bare ground maintenance, the following steps will reduce the environmental hazard.

- A portable sand/salt bin erected inside a heated building will keep the material at proper consistency and eliminate leaching.
- Limit the use of salt to hills and rises, and use sand on flat ground.
- Install a baffle at the rear of the salting unit to limit bouncing and rolling of salt to the width of the truck. The driver will not need to turn the machine off to avoid spraying pedestrians or passing vehicles. Constructing the baffle is a simple matter. Use ⅜-inch reefer rod bent into shape to receive a canvas skirt (Figure 6-18).
- To counteract salt injury, apply gypsum and nitrogen to the trees and woody plants along the salting route. Gypsum counteracts the effect of salt by reacting with the cation of the salt rendering it unavailable to the plant. The resultant product is highly soluble and readily leaches from the soil.[3]
- Install concrete curbing in critical areas to control runoff.

Holy Cross College has employed these methods since 1977 and has observed no salt damage to the environment. Moreover, there has been visible improvement in the condition of previously damaged trees, and an excellent safety record has been maintained.

Figure 6-18

6.9 CONCLUSION

The importance of a well-maintained campus is beyond measurement in terms of attracting students and faculty. In addition learning capacities increase if the attitudes of students are positive. These attitudes are greatly influenced by surroundings, and the aesthetics of a beautifully maintained campus contribute significantly.

In order to achieve these goals, an institution needs adequate staffing and funding of grounds maintenance and care. The most important factor is a person of leadership, knowledgeable in this subject, with a sincere interest in the work. Continued care of a campus cannot be guaranteed without the proper equipment and supplies. And as in all maintenance operations, adequate funds are needed to achieve success.

END NOTES

1. American Association of Nurserymen, Inc., 230 Southern Bldg. 1425 H Street, N.W., Washington, D.C. 20005.
2. Dean A. Ramsey, "Safety and Health Testing Programs for Hazardous Chemical Handlers" *Proceedings of the Sixty-Ninth Annual Meeting of the Association of Physical Plant Administrators of Universities and Colleges* (Washington, D.C.: Association of Physical Plant Administrators of Universities and Colleges, 1982), pp. 91-106.

3. Bruce R. Fraederich, plant pathologist, "Salt Injury to Ornamentals" *Technical Report of Bartlett Tree Research Laboratories*, Stamford, Connecticut 06905.

CHAPTER 7

Custodial Services

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Custodial Superintendent
University of Minnesota

7.1 INTRODUCTION

Management's goal is to provide the most efficient, versatile, and economic custodial service program possible. In light of budget reductions, a program designed to offer the best custodial service possible is a must.

Establish Priorities and Standards

There is an unlimited potential for programming standards. Priorities must be established, especially when budget reductions are critical. Health requirements have top priority, but as routines and duties are evaluated, frequency schedules can usually be altered. Priorities must comply with the needs of individual institutions or facilities.

A general guideline can be determined for priorities of service. Some areas to note include opening and closing of buildings, setups and special events, general cleaning of all areas and frequency of carpet shampooing, floor stripping and waxing, pool cleaning, window washing, extermination, trash removal, health science/hospital standards, and furniture moving. Establishing service priorities requires determining what services can be offered, and how often, using available funds.

Building contacts or liaisons can provide valuable help to any custodial department. Supervisors and managers meet monthly with building representatives to ensure adequate service. A log book is assigned to each contact person so daily comments may be recorded. Supervisors and custodians have daily access to this log and respond appropriately. This places accountability with the responsible parties—supervisors and custodians.

Specific standards can be detailed or generalized for flexibility. A few examples follow, but each institution should develop its own set of standards. Such standards are always subject to change and can be adjusted to fit economic times or priorities.

Organization

Care must be given so organizations do not become too heavy with supervisors or managers. Institutions vary tremendously in size, so the following are staffing guidelines for consideration.

- A department head.
- Managers of areas (if institution is large).
- Supervisors (controlling 15 to 20 job assignments).
- Project and relief crews per area (required for consistent performance). These crews fill in for absences, strip and wax floors, shampoo carpets, and perform special duties.
- Specialty crews such as window washers.

Supervisory personnel should not belong to the regular employee union. Building foremen or leadmen should not be used because this is the supervisor's job. Proper use of the first-line supervisor is critical.

7.2 PLANNING AND SCHEDULING

Facilities Inventory

Many institutions have a computerized system that provides a complete usage description of each building, room by room. Square footage (gross, usable, and unassignable) is also given. This information can be used to plan assignments, develop time standards, and determine work force requirements.

Computers are being used by some institutions to schedule assignments according to facility design. When custodial services must economize, a computerized program for redesigning service assignments helps simplify the process. See Appendix 7-A.

Floor Surfaces Custodial services must supply information for all planning and development efforts. Floor surfaces, once in place, become the responsibility of custodial services. Carpet has a higher initial cost than asbestos tile and may be more expensive to maintain if not properly selected and installed.

Many different floor types have come into use in the last few years that require special products and care. Do not use inferior products to save money when the proper, more expensive product will improve aesthetics and ease labor. A proper maintenance program must be considered within budgetary constraints. Designing a program of intermittent maintenance is better than no plan at all. The designers and occupants of facilities should help determine frequencies. Maintenance managers must educate those groups regarding custodial budget restraints and costs of maintenance.

Restrooms Public restrooms must be cleaned daily, while private individual restrooms may be serviced less frequently. Standardization of dispensers throughout the campus is critical. Periodic work such as scrubbing floors, walls, and partitions is necessary to maintain health standards.

Walls/Windows Cleaning wall spots is usually a custodial responsibility but wall washing may or may not be a custodial service. Spot cleaning should be scheduled on an ongoing basis to prevent accumulation and detract from appearance. This routine must be closely supervised and the work force continuously reminded of this important task.

Wall washing is time-consuming and usually only occurs prior to painting. In some union shops, wall washing comes under the painter's job description. There are exceptions—walls in restrooms, restaurants, health science, or hospital areas that must be regularly scheduled and maintained.

Window washing can be separated into two categories: (1) door and entry glass that belongs on the general custodial job description, and (2) all building windows on all floors that require a special window crew well-trained and equipped to handle the specialized duty. Windows need not be washed more than once annually and longer periods may be considered. A contractor can be used for such infrequent projects. Ideal windows are those that can be cleaned on both sides by rotating the window.

Furnishings/Equipment Custodial departments have a tendency to overstock equipment. A total assessment should be made so personnel are properly equipped and all equipment for specialized duties is available. Proper planning and control can assure availability of all labor-saving equipment and assess future needs.

Avoid common mistakes. Don't buy 16-inch buffers when 19- to 20-inch buffers were specified. Buying a cheaper piece of equipment that has a short life span or does not perform properly is not a wise use of limited funds. Quality is important but paying for a name, or luxuries, is not. Again, standardization of equipment alleviates many repair problems and simplifies the system.

Cataloging Space According to Usage

Depending upon the institution's size, cataloging space can be a relatively simple or awesome project. Much information about classroom usage may already be computerized; thus, custodial operations can build on this valuable tool. Space utilization determines time requirements and scheduling. If usage is heavier in one area than another, work loads may not be equal.

Office Custodial routine, frequency, and specific areas of office cleaning need to be determined. Personal items (carpets, pictures, ashtrays) should be the responsibility of the occupant. An example of a modified routine can be found in Appendix 7-B for offices and similar areas.

Classroom Custodial routine, frequency, and specific areas of classroom service should be determined. At institutions with extensive evening programs time-of-day scheduling will be modified. See Appendix 7-B for an example of a modified routine and frequency schedule.

Laboratory Custodial routine and frequency must be established. Laboratories vary from general classroom to critical research to medical functions. Individualized lab routines may be required to meet the needs of occupants and activities conducted in an area. See Appendix 7-B for generalized health and non-health routines.

Public Space Public spaces should be cleaned on a daily basis. Again, custodial routine must be determined. Appendix 7-B provides a modified version as an example.

Library Custodial responsibilities and library staff responsibilities must be delineated. An individualized program can be arranged within budgetary guidelines. General usage areas should be classified as classrooms or public spaces. Library offices are recognized as other offices on campus.

Athletic The athletic areas have special needs. Gyms, locker rooms, saunas, pools, and other hygiene areas require special attention. Individualized maintenance routines should be established in cooperation with the athletic department. Areas similar to other facilities fall under standard guidelines.

Other Areas Giving the best service within budgetary guidelines is the main criterion for any area. If an area has special uses or problems, the concerns must be evaluated and addressed. Custodial routine and frequency should be determined by the custodial department. Requests, or needs exceeding the budgetary guidelines for service, must be charged to the requesting department or group. A charge-back system needs to be developed to handle this effectively.

Staffing Requirements

The number of custodial workers needed to cover all aspects of custodial services varies. General methods and standards can be used but must be modified to fit each institution.

The variables that influence staffing needs include climate, traffic, usage (hygiene, general public, food area), type of facility (athletic, medical office, classroom), benefits (sick leave, vacation allowances), equipment in use (lack of labor-saving equipment requires more staffing), building security, shift time, ability and motivation of employees, and routine and frequency.

The following outlines give a basic standard for determining staffing. As individual assignments are developed, an accurate work load can be determined and corrections made, if needed (see Appendixes 7-C and 7-D).

Square Footage Method This method is a general category method and can be used for the institution as a whole or applied to the types of areas served.

Example: General campus area (offices, classrooms, public, etc.)
4,000 square feet for each workhour
Health sciences areas (treatment, patient, research labs, etc.) 2,000 square feet for each workhour

Square footage should represent usable square feet, not gross square feet of a facility, to establish staffing needs.

The standard square footage multiplied by eight hours worked each night equals the square footage for each full-time equivalent (FTE) employee.

4,000 sq.ft. × 8 hrs. = 32,000 sq.ft/FTE for general space
2,000 sq.ft. × 8 hrs. = 16,000 sq.ft/FTE for health sciences areas

There is no rule for how many square feet can be serviced in an hour. Each institution varies depending upon routine, frequency, and other needs that fall under custodial services. Other professionals, similar institutions, and the *APPA Costs and Staffing Report* can provide general guides for standards.

Area Method The area method is the most commonly used and accepted, and most commonly abused method. Areas are assigned for convenience (one worker for each floor) without consideration of actual square footage or time standards involved.

The area method of work assignment should be planned with the "total area" concept. This means the custodian has full responsibility for all custodial services in this area, including waxing and shampooing (with the exception of major projects). This allows employees to develop pride in their work, give personal service, reinforce good public relations for the department, and be accountable. Again, assignments must be based on the department's standards of duties and frequency. A total job description that explains duties and frequencies, along with a complete physical map showing total area involved, should be supplied at the orientation and training.

Time Standards Universal time standards are available that can serve as guides. Managers should develop their own time standards based on thousands of square feet cleaned each hour, or the number of minutes needed to clean a fixture. Once time standards are established, programming new buildings or remodeled areas becomes routine.

Time standards allow for equal work loading. There can be more than one standard for individual items, ranging from light to heavy, based on usage and quality. Again, see Appendix 7-A, which includes designated time standards.

Take the following steps to establish a time standard system:

1. Determine task and frequencies of all duties.
2. Determine the average time it takes to perform each task (usually measured in minutes/1,000 sq.ft.).
3. By combining information in steps one and two, make individual assignments and determine staffing levels.

Scheduling

Scheduling of custodial personnel should focus on efficiency and quality of cleaning. If an institution has heavy evening activity, a late-night shift may be the answer. If custodians have to work around people, production and quality may decline.

Care should be taken not to overstaff day crews. This results in excessive unscheduled time available (for emergency calls). Efficient use of the day shift will reduce the staff needed during evening cleaning hours.

Shift Schedules The majority of cleaning work is performed during the evening shift. The amount of day shift cleaning in buildings should be kept to a minimum. Although the implementation of a day shift cleaning operation may slightly reduce the amount of energy consumption, improve morale, and reduce absenteeism, cleaning work can best be performed when buildings are mostly unoccupied. Although a custodial staff will be required on the day shift, most of the custodians should be assigned to the evening shift.

The benefits of an evening cleaning shift outweigh the disadvantages.

- Scheduling of cleaning work in each building is easier.
- Delays from interruptions from faculty and staff members, students, and others in the building are minimized.
- Proper supervision of custodial personnel is easier.
- Building security increases when the buildings are occupied during the evening shift.
- Concern for building occupants' safety is reduced.

These benefits increase the productivity of custodial personnel. The disadvantages of night shift cleaning involve increased energy consumption to heat and light buildings, and motivating employees. These disadvantages may be lessened by increasing the effectiveness of first line supervisors and by involving custodians in the energy awareness program.

Day shift workers open buildings and do some routine cleaning before the building occupants arrive in the morning. The earlier shift time also allows custodians to participate in snow removal as needed.

Scheduling by Skip-Cleaning Skip-cleaning is a valuable management tool during budget reductions. Areas that had been cleaned on a daily basis may be changed to twice-a-week cleaning (or any other variable). If a job assignment is totally offices, more than a 50 percent reduction of labor can be realized. The limitations of skip-cleaning are dictated by health and hygiene standards. Public bathrooms should not be placed on a skip rotation.

This program is excellent for increasing square footage of personnel and reducing the work force, as long as certain standards are established and maintained.

Supervision and Inspection

Each supervisor should thoroughly inspect all routine cleaning in his or her zone of responsibility at least monthly. Management should accompany each supervisor on an inspection at least quarterly. During the area inspection, notations of excellence in housekeeping, as well as areas for improvement, should be documented with a list of action items required to improve unacceptable situations.

Supervisors should spend most of their time in the field meeting with workers in their respective buildings. This daily contact between the custodial worker and supervisor motivates individual employees to perform at their best. Each supervisor should have an office strategically located within his or her supervisory zone. The office may be combined with a satellite stock room. However, a measure of privacy must be available to each supervisor so he or she may counsel employees without interruption. If more than one supervisor shares an office, the department should install partitions or provide a separate conference room so discussions with employees may be conducted privately.

A standard inspection form should be used to assess the quality of housekeeping in each area and to show each worker's progress on a month-to-month basis. The form should be used to evaluate employee performance and help the inspecting supervisor communicate expectations to the employee. The inspection form should always be reviewed *with* the custodian responsible for the area inspected. Recommended inspection and evaluation forms are shown in Appendixes 7-E and 7-F.

During the implementation of this program, supervisors will be trained in the proper way to inspect and counsel employees based on inspection results. Each supervisor must understand that an inspection program is vital to improving housekeeping quality at the institution. Each supervisor reviews the work of inspectors and keeps at least six months of inspection reports in each employee's personnel file.

Supervision/Custodial Ratios The number of employees assigned to a supervisor should not exceed 20. Several factors may contribute to a limited ratio:

- Large size of the institution.
- Bargaining unit of employees, which due to rules and guidelines, demands substantial time.
- Reports and checklists required by the department.
- Liberal vacation time that demands the ability to overlap.
- Day and night shifts require separate supervision crews.

Supervision can be reduced to any level but there are limitations to quality and quantity of production. The following are useful in assessing supervision needs:

- Dollar percent of total budget. Since supervision is part of overhead, a maximum of 8 percent for first-line supervision with a minimum of 4 to 5 percent should be established. Total overhead expenses should not exceed 12 percent.
- Use of personnel ratios. Ratios of 1:15 to 1:20 employees for each supervisor are acceptable. The number of assignments should be considered in this ratio. The fallacy of this method is that the operation or work is not taken into account, just the numbers.
- Square footage method. This method has no valid reasoning behind it. It varies with distance between buildings, level of cleaning, and concentration of personnel. A supervisor may handle 300,000 square feet in a health science facility and 600,000 square feet in other campus areas. It is usually based on staff ratio per employee.

Well-trained, top quality supervisors can direct more novices than the untrained, average supervisor. A supervisory training program can develop higher quality supervisors capable of expanding their work load.

Duties and Responsibilities of Supervisors No department can rise above the quality of its first line supervisors. Therefore, development of first-line supervisors is vital to the success of any housekeeping program. Supervisors must receive regular training and try to learn from their experiences and the experiences of others. Basic areas a supervisory development program should cover include—

- Supervisors should be taught the proper ways to approach, supervise, and counsel employees assigned to their area. This may be accomplished through role playing and discussions with all levels of supervision.
- Supervisors should be assigned a reading program that includes information on both supervisory practices and housekeeping techniques.
- All supervisors should be required to attend housekeeping management training classes and seminars.
- A supervisory training manual should contain readings on such subjects as the role of the first-line supervisor, supervisory philosophy and attitude, worker psychology and morale, motivation, problem solving, consistency in supervision, discipline, communications, custodial training, and supervisory inspections.

First-line supervisors must understand their responsibilities for planning, coordinating, and directing custodial operations in their assigned areas of the campus. The major responsibilities of supervisors are to—

- Directly supervise the activities of custodians.
- Assign employees to perform housekeeping and sanitation tasks. Includes scheduling off-days and vacations, checking that all assignments are filled at the beginning of the shift, and approving time records for subordinate employees.
- Make daily contact with employees assigned to his or her zone and counsel employees on day-to-day operations and problems.
- Make frequent inspections of buildings in the assigned zone to ensure that work is being accomplished in a proper and orderly manner.
- Keep necessary records and prepare reports concerning the custodial operation and work performance. Make recommendations to the custodial principal.
- Under the direction and supervision of the custodial principal, managers coordinate evening cleaning operations with day cleaning operations, incorporate new housekeeping developments into the custodial program within their zones, and arrange for the supply of housekeeping material and equipment needed to maintain equipment performance. In addition, supervisors establish priorities and control measures for routine and special services within and between academic buildings on campus, conduct housekeeping, safety, and fire prevention training sessions for all assigned personnel and advise on operational and technical guidelines for the department.

7.3 CUSTODIAL TRAINING

Custodial training should consist of three parts: orientation, formal classroom training, and continuous on-the-job training. Initially, senior supervisors should present formal training on a rotating basis, or each senior supervisor should select those areas in which he or she feels particularly competent. On-the-job training should be done by the supervisors on a one-to-one basis with custodial workers. Supervisors should assist senior supervisors in conducting classroom training after supervisors have participated in training and practiced among themselves.

Every custodial worker, regardless of tenure, should attend training classes. At least one training class should be conducted every week for a group of 10 to 12 custodians. Initially these classes should follow this format—

- Visual presentation of subject matter using slides or other visual aids and verbal explanations (about 20 minutes).
- Practical demonstration of the main point in the presentation (about 20 minutes).
- Participation by the class attendees, including a question-and-answer session (about 20 minutes).

The training classes, about one hour in duration, should be scheduled and announced in advance. A training schedule showing subjects and dates should be prepared and distributed to supervisors. They can then schedule the attendance of custodians in their areas. Each supervisor should maintain a record of attendance from his or her area to ensure that all custodial workers attend all classes.

Training for new employees should begin with their orientation. During the first few days of employment, attitudes toward work, attendance, performance, and productivity are formed. New employees should not be placed on the relief crew if at all possible. A new employee assigned to a specific area in a building will contribute more to the custodial program more quickly.

Supervisors should keep the training program in mind when inspecting their areas. The results of an inspection can reveal which workers are weak in the performance of specific jobs. Training can then focus on helping workers bring their performance up to standard. Supervisors should note which custodial workers produce superior results and which ones show marked improvement as a result of the training program. Recognize those workers who have completed a specific number of hours of formal training with a certificate awarded at an employee meeting. A symbol may also be added to the employee's identification badge as a means of recognizing completion of required training.

In-House Training Programs

In-house programs are a must. A total training program must be developed (with the help of a personnel training specialist) that meets the methods and designs of the institution. This program can be taught by personnel department staff but supervisors from the plant department should conduct the training. An experienced person, who has done the work, knows the problems and preferred techniques is a necessity.

Specialized help may be needed for some issues. An environmental safety group may develop courses on radioactive and hazardous waste, but custodial training personnel should present the information to the work force.

Use of Training Consultants Training consultants can be expensive. Often class seminars for a day or two are arranged covering a variety of subjects that only scratch the surface. It is impractical to hire a consultant repeatedly to train personnel. If there are no qualified trainers within an institution, such a person should be hired to do the research, development, and training for a department. A training program that encompasses the institution's needs and functions is the goal.

Recommended Training Course

The following is a general guideline for a custodial program and supervisory/staff training program.

Custodial

- Orientation covering all general policies, rules, and procedures for the institution.
- Formal classroom training.
    1. "How to" cleaning procedures.
    2. Specific items (hazardous waste management, sexual harassment issues).
- On the job training. A follow-up on classroom procedures and any specifics in area (operating rooms, showers, saunas, etc.).

Supervisory

- Role.
- Philosophy and attitude.
- Worker psychology and morale.
- Motivation.
- Handling grievances.
- Consistency in supervision.
- Discipline
- Communications.

- Custodial Training.
- Inspection procedures and program.

Additional areas that may be needed include custodial charge policy, other guidelines, any internal procedures.

7.4 EQUIPMENT REQUIREMENTS

Assessing equipment needs ranges from superficial review to detailed analysis. Available products and their quality must be determined through research. Equipment should be purchased to cut labor costs or add quality and efficiency to the operation. The bargain brand is usually not the best buy in the long run, but some products perform well and may be appreciably less expensive than the name brand. Also, top-of-the line equipment may not have been provided for in the budget. The type and frequency of use should determine which equipment will provide the best service.

Equipment standardization is important and should only be changed when a new product has proven to be superior in performance to those currently in use. Standardization of equipment facilitates—

- Interchangeability of parts.
- Ease of transferring equipment from one area to another, and having the operator know how to use it.
- Interchangeability of attachments.
- Supplier service.
- Future equipment purchases.

Maintenance should be on a preventive schedule, as well as a continuous repair service. Servicing equipment "in house" as much as possible is also recommended.

A record of where equipment is stored and to whom it is assigned should be kept by the supervisor and general mechanic. A simple schedule and card system should be maintained by mechanics to record the maintenance activity for each piece of equipment and to show when equipment is due for servicing. Additional equipment should be maintained to replace those machines in service when they are repaired. Each worker must have the proper equipment available at all times to complete his or her assignment.

Floor Machines

Rotary Floor Machine: 18" to 20" high-speed or variable-speed (approximately 270 rpm), single-disc, 1.5 h.p., 75-foot cord. (Similar to Clarke HS 2000 with Drive plate similar to 3M Insta-Lok.) Use: scrubbing, stripping, buffing.

Automatic Scrubber: battery powered, 200 rpm brush speed, 24" to 32" scrub path, 10- to 15-gallon solution and recovery tanks, squeegee. (Similar to Clarke TB-32 Advance Convertamatic 24B or Tennant Model 42). Use: scrubbing open resilient and masonary floor surfaces.

Vacuum Cleaners

Wet/Dry Vacuum: 1.0-to 1.5 h.p., bypass-type tank vacuum with dry and wet pickup capabilities, 5- to 8-gallon water recovery capacity, drain valve, automatic shut-off (microswitch desirable), polyethylene tank construction, all wet and dry attachments. (Similar to Advance Sprites.) Use: stripping floors, water spills, rest room scrubbing, miscellaneous project cleaning, routine carpet cleaning of hard-to-reach areas, drapes, blinds, HVAC vents.

Upright Area Vacuum: 22" to 28" cleaning width, separate vacuum and brush motor, fully enclosed disposable paper filter bag, brush adjustment, overload protection. (Similar to Advance Carpetriever or Clarke Carpetmaster 578.) Use: large open or uncongested carpeted areas.

Standard Upright Vacuum: 11" to 16" cleaning width, single motor driving both vacuum and beater bars, exposed cloth filter bag, enclosed disposable paper bag, brush adjustment, overload protection. (Similar to Hoover 918, Clark 576A, or Advance Carpetwin 16.) Use: normal and congested areas.

Dry Foam Carpet Shampoo Machine: 18" to 20" brush width, self-propelled, forward and reverse, cylindrical brush, brush adjustment, 3- to 4-gallon solution tank, 3-position foam control switch. (Similar to Advance Carpetron 18 or Clarke CM-20.) Use: periodic dry foam shampooing of all carpets.

Water Extraction Unit: 8- to 10-gallon solution and recovery tanks, thermal and solution protection devices, 15" to 20" solution and pickup hoses, 80 to 90 pounds net weight, 15" width powered brush and extraction head. (Similar to Clarke 935 with model 915.) Use: wet cleaning carpets in conjunction with the dry foam method.

Wall Washing Machines

Pressure Washer: 1.5 h.p. motor size, 40 feet of ⅜" high-pressure hose with dual nozzle gun, chemical injection (aspirating), cart mounted, volume pressure: 3 gpm, 600 p.s.i. (Similar to Advance model 13 SL.) Use: cleaning shower rooms, locker rooms, restrooms, kitchens, and waste receptacles equipped with drains.

Carpet Pile Lifters

Pile Lifter Vacuum: aggressive heavy-duty upright carpet vacuum, pile lifter brush, exposed filter bag, brush adjustment. (Similar to Certified Pile-Brush.) Use: aggressive, project-type cleaning and realigning carpet pile after shampooing, entrance and elevator mats.

Window Washers

Entry and first-floor glass should be cleaned by the custodial staff. Contracting of all other high glass may be an economical measure if not done on an intense, regular basis. The section under Hand Tools gives general information for proper window equipment needed for low glass.

Special tools and equipment are needed for high glass inside and out. Top quality equipment that exceeds all safety requirements is needed. Safety must be primary at all times, and the window washer supervisors should choose equipment since life safety depends on proper selection. This equipment should be under restricted use.

Custodial Carts

Carts: 5-bushel capacity, plasticized waste collection bag with hook and eye attachment, collection bag support shelf, 4" diameter swivel casters (all four wheels), tool holder clips, metal receptacle attached for emptying ashtrays. (Similar to Walton-March, Inc., Whippet model WM-1064.) Use: routine transportation of chemicals, tools, and supplies and for trash collection and removal.

Hand Tools

One-Ounce Dispensing Pump: size to fit 1-gallon chemical containers. Use: dispensing chemicals from 1-gallon containers.

Sponges: hand size, cellulose construction, different colors (yellow—general cleaning; blue—sinks, drinking fountains, showers; red—toilets and urinals. Use: spot cleaning walls, doors, furniture, and cleaning of drinking fountains and rest room fixtures.

Spray Bottles: plastic bottle with pistol-grip sprayer, 22-ounce capacity, 1-ounce graduated raised markings, adjustable nozzle. Use: spraying solutions of detergents, germicides, shampoos, floor finishes, and glass cleaners.

Measuring Cups: plastic, 8-ounce capacity, 1-ounce graduation (raised) on side. Use: measuring chemicals.

Funnel: plastic, 2-inch top opening, ¼-inch bottom opening, approximately 2½ inches overall depth. Use: measuring and mixing chemicals.

Percolator Brush: ¼- to ½-inch diameter by 2-inch long brush of nylon, 6 ½ inches overall length. (Sometimes referred to as a test tube brush.) Use: cleaning drinking fountains and sink drains.

Window Squeegee: 10-inch width, rubber blade, straight design, removable 8-inch handle. Use: washing entrance windows, partition glass (projects), tiled walls in shower.

Push Broom: horsehair and plastic fibers, 60-inch wooden handle, 18-inch wooden block width, 3 ¼-inch trim. Use: general sweeping of concrete floors and wet soil removal in rest rooms, vending areas, and food preparation areas.

Utility Brush: stiff nylon bristles, plastic block, 20-inch overall length, 2-inch trim, 3 ½-inch by 3 ½-inch brush area. (Sometimes referred to as a "Gong Brush.") Use: spot-cleaning carpets and upholstery and for maintaining dust mop heads.

Deck Brush: palmyra fibers, wood block, 10 inches by 2 ⅞ inches with 60-inch wooden handle, 2-inch trim, rubber squeegee blade set into side of wooden block. Use: routine and project scrubbing of rest room floors, showers, and other ceramic tile and concrete floors.

Cove Brush: triangular shaped brush, grit-impregnated nylon bristles, 1 ⅝-inch trim set in wooden block, 48-inch wooden handle. Use: routine and project scrubbing of baseboards and coves.

Dusting Tool: 12-inch wooden handle, metal frame, cotton mop head, approximately 5 by 7 inches, washable, untreated. Use: miscellaneous dusting of walls, ledges, furniture and fixtures.

Dust Mops: swivel mop head holder; steel frame, wooden 60-inch handle; cotton mop head; sizes 24 inch, 36 inch, and 48 inch by 13 inch; pretreated and packaged in individual plastic bags. Use: dust mopping smooth composition-type floors. (Mop heads should be sized according to the layout (openness or congestion) of area being dust mopped.)

Lobby Brush: two-position handle (upright or angled), horsehair and plastic blend bristles, 33-inch handle, 8 ¼-inch by 1 ⅜-inch size block, 2 ½-inch trim. Use: sweeping in hard-to-reach places of carpeted or tiled floors.

Dustpan: plastic construction similar to Rubbermaid dustpan. Use: pick up of dry soil after mopping and sweeping.

Bowl Mops: synthetic yarn head (acid resistant) with plastic handle, plastic wringer cover. Use: cleaning rest room urinals and toilets.

Plastic Pail: 10-quart capacity, round with pouring spout, handle, 1-quart raised graduations on side. Use: mixing and transporting chemical solutions for rest room care and spot mopping.

Floor Machine Pads: similar to 3M Thickline (black for stripping, brown for scrubbing, orange for high speed buffing and red for regular speed buffing). Use: stripping and buffing floors coated with floor finish, scrubbing non-coated floor surfaces.

Wet Mop: spring-type frame (no wing nuts) on 54-inch wooden handle, mop head of cotton fibers with looped ends and stitched band across mop strands, 16-ounce and 24-ounce weights, color coded for rest room and general mopping. Use: 16-ounce for spot mopping and rest room damp mopping, 24-ounce for damp and wet mopping large areas.

Routine Mopping Outfits: plastic bucket with carrying handle and reinforced lip, 18-quart capacity to fit custodial cart, removable or no casters, "wet floor" embossed on side. Wringer of plastic reinforced or metal construction, side pressure squeegee design, down-pressure handle, to fit 18-quart mop bucket and 16-ounce mop. Use: project mopping and routine mopping of large areas.

Floor Squeegee: 24-inch width, rubber blade, curved ends, 54-inch wooden handle. Use: policing of spills and project-type stripping, scrubbing, and sealing.

Counter Brush: horsehair or plastic with flagged ends, 8-inch brush length, 2 ⅛-inch trim, 13 to 14 inches overall length, wooden block. Use: pick up dry soil after dust mopping and sweeping and dusting irregular surfaces such as grille work and railing supports.

Window Brush: 8-inch by 2 ½-inch of 100 percent horsehair, 2-inch trim, 8-inch handle. Use: washing entrance windows and partition glass (projects).

Sponge Mops: cellulose sponge head, built-in squeezer, 48-inch wooden handle. Use: project wall washing in rest rooms and other areas.

Pump-Up Sprayer: 1- to 1.5-gallon capacity, stainless steel, adjustable nozzle, carrying handle and strap. Use: spraying chemical solutions on large rest room and shower room fixtures, walls, and floors.

Polyurethane Eraser: 18-inch size with synthetic untreated chamois skin back. Use: routine dry cleaning of chalkboards. (Note: do not use water to clean slate or synthetic slate chalkboards.)

7.5 CUSTODIAL SUPPLIES

Supplies are a matter of comfort and efficiency. They can be purchased concentrated, which is more economical but requires mixing control, or premixed. Buying from reputable suppliers usually guarantees a good product. Suppliers are also helpful in solving specialized cleaning problems that arise. Many products are available; therefore only general recommendations follow.

Cleaners

Be sure to standardize cleaning products throughout the operation, and purchase the correct cleaner that does the job. (See Appendix 7-G).

Waxes

Important factors are durability, ability to be scrubbed, slip resistance, ease of application, ease of removal, and buffability. Products can be purchased that require a little or a lot of buffing, thus influencing labor costs. Appendix 7-H shows a general guideline for two types of waxes (finish).

Sealers

If used in combination with wax, the sealer must be compatible. If concrete or terrazzo is to be sealed, a special type product can be used or a good sealer meeting wax specifications can be used. There are general sealers on the market that can be used for most stone flooring.

Paper Goods

Standardization of dispensers allows for volume purchasing to achieve savings. The kinds of product and dispensers to purchase are a matter of preference. Obviously economics is a factor, but determining usage and why one product is preferred to another is a matter of personal opinion. Accepted guidelines are that roll paper towels are more economical than fold towels, and double roll-lock toilet tissue dispensers are more economical than single.

7.6 CONTRACT CLEANING

The pros and cons of departmental versus contracted cleaning have been much discussed. The needs and desires of an institution should first be determined before selecting one cleaning method. Often changing from a long-term familiar internal service to an unfamiliar outside organization that is not part of the institutional community is the largest deterrent.

The consideration may be a humanistic versus good-business approach. Colleges and universities tend to show greater concern for people, jobs, benefits, and security than for economics, efficiency, cost reductions, and demand performance. The ideal is a compromise of both systems, which requires an extensive effort on management's part. Hiring qualified, experienced personnel in the custodial area and developing a complete custodial program can be achieved.

A contractor can be used to handle isolated areas or special needs (windows, floor sanding, carpet extraction). Contractors may be used for tasks management does not wish to expand a program to perform or where, after thorough analysis, a significant cost reduction can be realized.

Pros and Cons

Pros Contractors promise and can deliver the following:

- Lower costs
    1. Reduction of payroll and personnel needs.
    2. Elimination of benefits costs.
    3. Supply, equipment, and repair cost eliminated.

- Tight budget quality control standards.
- Increased efficiency through techniques of scheduling, training, etc.
- Better trained and qualified supervisors and managers.
- Evaluation and updating of all current methods.

Cons The arguments against contracting include:

- Higher costs
    1. Profit motivation may result in cut corners, or many "extras" can be charged for desired results.
    2. Supplies, equipment, benefits, overhead, wages, management are paid in addition to profit.
    3. Once a contractor is established, then charges increase.
- Eliminates long-time employees and disregards their years of dedication and benefits.
- Contractors pay less and will attract less stable employees.
- All the needs and desires of the institution will not be met and could cost much more. Lose flexibility.
- If an institution has, and is continually developing, an efficient program, a contractor is not needed.

Evaluation Factors

All in-house custodial operations should be evaluated completely. If demands and expectations are not being met and redesigning the operation is not possible, then contractors should be considered. The following offer guidelines for consideration.

Need Are all expectations from efficiency to economics being met?

Expectations Managers must determine services to be performed and cleaning levels. Work specifications, including all "other" items that fall under the category of "custodial," must be recognized. This not only helps evaluate the internal organization but is a must to supply to a potential contractor. Specifications must be clear and concise in order to eliminate all hidden costs and allow for appropriate building requirements. This may enable administrators to see how extensive and important the custodial service is. Ask other institutions which contract work about potential problems and benefits.

Bid Selection Contractors can cover a wide range of capabilities. In metropolitan areas small local companies and large national contractors are available. The contract price can vary widely. Good business practice eliminates bids not within the range of competition. Depending on campus size, several contractors may be more appropriate. Check references and look for quality of performance, supervision, flexibility, and stability of personnel.

Proposals Check proposals thoroughly. Make sure all desires and needs are being considered. Let the contractor state, in writing, programs that will ensure a quality job. A contractor may have forms, training programs, established backup (out of state, national headquarters).

Communications and Follow-up The institution must maintain a contact or liaison person(s). The contractor's work must be inspected to assure adherence to the contract. The campus community needs someone to handle complaints or special projects. Someone must have the responsibility and authority over budgetary spending. The contractor may be doing the work, but the institution remains responsible for the results.

Economics

Economics is usually the reason a contractor is considered—union wage scales; labor actions; increasing costs of benefits, supplies, and equipment—the list seems endless. Many institutions use a modified cleaning schedule to eliminate the highest cost factor—labor.

A contractor may save an institution money three ways: labor wage, benefits, and supplies and equipment.

Labor Contractors can pay as much as several dollars an hour less than an institution's highest paid custodians, especially if a union shop is involved. This is true when contractors can use their own people. If the contractor must keep current personnel and wages, then an efficient in-house program is just as economical.

The drawbacks of reduced wages, which can significantly reduce custodial cost, are instability of the work force, a transient work force (no one can usually support a family on a contractor's wage), less qualified personnel, and inexperienced workers.

Contractors generally employ more part-time employees who make lower wages and require no benefits. More work can be accomplished for less cost. Through good hiring practices a mature part-time work force can be established.

Benefits As stated above, hiring part-time employees can dramatically reduce costs. Most contractors offer only minimum benefits that are not attractive. If benefits were improved, that cost would be shared with the customer. There are national companies that offer better benefits and profit-sharing programs. If benefits are a concern, these firms should be considered.

Supplies and Equipment A contractor may wish to assume the institution's equipment through purchase or loan until all equipment is purchased. Paper products, plastic bags, and light bulbs usually remain the responsibility of the institution.

Remember that eventually the contractor will own all equipment and supplies. If a return to in-house service is desired, a major purchase of equipment will be necessary.

The cost of equipment and supplies is passed on in the cost of a contract. The contractor's purchase of economical and efficient products may or may not be a plus factor. Purchasing practices directly influence profits.

Contract Management

Contract management for institutions is a limited service that more companies are beginning to offer. If a strong union environment or a strong "institutional family" exists, an outside management team faces large obstacles to success.

Contract management is usually needed when an institution has a weak or ineffective management team. Outside managers promise greater efficiency with fewer employees, equaling lower costs. Many times they insist on using their own supplies and equipment for obvious reasons.

A management team needs good cooperation and acceptance. If those are not received, then failure is imminent. A management team is strictly that. A national pool of supervisors may be available to offer a variety of experience from which your custodial operation can benefit. They work for a profit, as well as to profit the institutions they serve.

7.7 "HOW-TO" CLEANING PROCEDURES

The following consists of duties, materials, and step-by-step instructions for performing routine custodial functions. These guidelines should be adjusted to meet each institution's training needs.

Emptying Trash and Cigarette Receptacles

Materials

Custodial cart with trash collection receptacle attached
Fireproof metal container attached to cart
Detergent solution in a plastic spray bottle
Clean cloths and sponges
Supply of plastic trash can liners
Metal polish

Preparation of Materials

Prepare a detergent solution in the plastic spray bottle according to the manufacturer's dilution instructions printed on the container. Dampen a cloth or sponge with the detergent solution and keep another cloth clean and dry.

Instructions/Emptying Trash

1. Empty the trash receptacles into the trash collection bag on the cart. Do not reach into the waste basket, but carefully dump the contents into the trash collection bag.
2. If the plastic liner in the waste basket is torn, soiled, or wet, replace it from the supply on the custodial cart.
3. If the inside of the waste basket is soiled, damp wipe the inside using the detergent solution in a spray bottle and a sponge or cloth.
4. Damp wipe the outside surfaces of the waste basket to remove soil and smudges. If the waste basket is stainless steel or other bright metal, use metal cleaner or polish to remove fingerprints.
5. When the plastic trash collection bag is full, remove it from the custodial cart and place it at the designated pick-up point for removal from the building. Be careful not to place a trash collection bag directly on carpeted floors, as liquid may leak through the bag and soil the carpet. Instead, place a folded plastic bag under the full bag to catch any spills that may occur.

Instructions/Emptying Cigarette Receptacles

1. Empty cigarette receptacles into the specially marked container on the custodial cart. Do not place contents of cigarette receptacles and ashtrays into the trash collection bag, since a fire may start if some cigarettes are still burning.
2. Using a damp cloth or sponge, damp wipe the cigarette receptacle with detergent solution from the plastic spray bottle. Wipe the interior and exterior of the receptacle with a clean, dry cloth. If the cigarette receptacle is stainless steel or other bright metal, use metal cleaner or polish to remove smudges.
3. Use a wire strainer to collect cigarettes from sand-type ash urns. The cigarettes will be trapped in the strainer while allowing the sand to sift back into the urn. Place the waste collected in the specially marked cigarette container on the custodial cart.

Cleanup

Rinse and wring dry the cloths and sponges used. Properly label the plastic spray bottle before it is stored.

Chalkboard Care

Equipment

One clean felt eraser
One clean, dry chamois skin or loosely knit soft cotton cloth
One damp cloth or damp sponge

Areas Where Applicable

The following method should be used on all types of chalkboards, slate blackboards as well as synthetic boards in common use. These techniques do not apply to the special boards designed for writing with water-base liquid crayons.

Preparation of Equipment

Clean the felt eraser and chamois skin or cloth, if necessary. The eraser should be vacuumed and the cloth or chamois skin shaken to remove dust. Never wash chamois skin.

Preparation of the Area

Collect all erasers and pieces of chalk in the chalk tray and move them to one end of the tray.

Instructions

1. Use the felt eraser to erase the entire board, except for boards or areas marked "SAVE" or "DO NOT ERASE."
2. After erasing, wipe the entire board with the chamois or cloth.
3. Damp wipe the chalk tray with a well-wrung cloth or sponge. Never apply a damp cloth to the board itself.
4. While wiping the chalk tray, collect and discard small chips of chalk.

Restrictions on Use

Do not place felt erasers with the erasing side down in a damp chalk tray.

Cleanup

After all chalkboards in an area have been cleaned, vacuum the felt erasers using an eraser cleaner or tank vacuum and wand. Shake the chamois skin or cloth and rinse the sponge or damp cloth used to clean the chalk tray.

Dusting Building Surfaces and Furnishings

Materials

Treated dust cloths
Short-handled dusting tool
Portable tank vacuum with attachments
Whisk broom

Areas Where Applicable

1. Horizontal surfaces include tops of desks, tables, cabinets, and similar surfaces, ledges, window sills, decorative moldings, wall-mounted HVAC vents, and venetian blinds.

2. Vertical surfaces include sides of desks, tables, cabinets, furniture legs, picture frames, doors, and moldings.

Instructions

1. Dust furniture surfaces using a treated dust cloth or a short-handled dusting tool. Items such as telephones, desk sets, and picture frames should be dusted, avoiding those things which appear too fragile to be handled safely. Papers, books, and other work material left on tops of furniture should not be moved. Never read or look through personal papers left on furniture.
2. A short-handled dusting tool should be used to dust wall surfaces up to approximately eight feet (such as ceiling-mounted HVAC vents) and most low surfaces (such as chair rugs, furniture legs).
3. Move the dusting cloth or tool over the surface to be dusted so that the soil is trapped in the fibers of the cloth. Avoid snapping, flicking, or shaking the dust cloth, which would redistribute the dust to other surfaces.
4. To dust decorative moldings, venetian blinds, upholstered furniture, and other irregular or rough surfaces, use a portable tank vacuum equipped with a soft brush attachment. Use a whisk broom to remove soil from crevices in upholstered furniture.

Cleanup

Vacuum clean dusting tool heads after use. If dusting cloths or tools become soiled, and therefore lose their effectiveness, send them to be laundered and retreated. If dust cloth is disposable type, and is no longer usable, place in the trash receptacle.

Furniture Polishing

Materials

Furniture polish in an aerosol can (furniture polish is one of few cleaning supplies that can economically be dispensed and used in aerosol form).

Several soft, clean cloths.

Areas Where Applicable

Good quality furniture polish may be used on almost any non-fabric surface—wood, metal, vinyl, plastic, etc.

Preparation of the Area

On desks, tables, and other work surfaces move all items (unless specific instructions have been given not to touch or disturb certain items) to one side.

Instructions

1. Unless specific instructions on the container of the product differ, hold the container eight inches away and spray the entire surface lightly.

2. Wipe immediately with a soft, clean cloth. Do not allow the spray to dry before wiping.
3. On narrow surfaces, where much of the spray may be wasted, such as chair arms, or on areas where the spray may wet and damage papers, spray the cloth and then wipe the area. Wipe again with a clean cloth.
4. After the exposed part of the surface has been polished, move all items onto the area and do the other part.

Cleanup

Rinse all the cloths in warm water, wring them so they do not drip, and hang to dry.

Spot Cleaning Glass

Materials

Glass cleaner solution in a plastic spray bottle
Several clean, dry cloths or paper towels
Measuring device

Areas Where Applicable

Any glass surface that is likely to be touched by someone. Glass doors, mirrors, and glass partitions are examples of areas that require frequent spot cleaning.

Preparation of Materials

If glass cleaning solution has not already been mixed, do so. Fill the spray bottle approximately ¾-full of water and add the appropriate amount of glass cleaning concentrate. Remember, instructions for the proper dilution are usually given in terms of ounces per gallon. Spray bottles normally hold between ⅛ and ¼ of a gallon. The amount of concentrate used should be measured accordingly.

Preparation of the Area

If spot cleaning is done on a glass door in a high traffic area, it may be necessary to prop the door open so the cleaning process and the flow of traffic do not interfere with each other.

Instructions

1. Spray visibly soiled areas with a small amount of glass cleaning solution. Avoid spraying so much solution that it begins to run or drip.
2. Wipe the area with a dry cloth or dry paper towel.
3. Be sure to wipe off any cleaner that may have gotten on frames or other non-glass materials that border the area cleaned.

Cleanup

Rinse and wring dry any cloths used. If the glass cleaning solution is to be left in the plastic spray bottle for future use, properly label the bottle before storing it. Dispose of any paper towels that were used.

Metal Cleaning

Materials

Neutral detergent solution in a plastic spray bottle
Lotion- or creme-type cleaner
Clean cloths
Measuring device

Areas Where Applicable

Any exposed interior metal surface, structural or decorative. Metal parts of doors, metal railings, and other metal surfaces frequently touched require regular cleaning.

Preparation of Materials

If a neutral detergent solution is not available in a spray bottle, it must be mixed. Fill the bottle approximately ¾-full of water and add the appropriate amount of concentrate. Remember, instructions for diluting detergent are usually given in terms of ounces per gallon of water. Spray bottles normally hold between ⅛ and ¼ of a gallon, so measure the amount of concentrate accordingly.

Preparation of the Area

If metal to be cleaned is on a door in a high traffic area, it may be necessary to prop the door open so the cleaning process and the flow of traffic do not interfere with each other.

Instructions

1. Spray the metal lightly with the detergent solution. Wipe the area dry with a clean cloth.
2. For stubborn soil, it may be necessary to use the lotion- or creme-type cleanser. Put a small amount of the cleanser on a damp cloth and wipe the area clean. Remember, lotion or creme cleanser is abrasive and should be used only if soil does not respond to the detergent solution. Never use lotions or cremes on highly polished metal.

Cleanup

Rinse and wring dry any cloths used. If the detergent solution is left in the plastic spray bottle for future use, properly label the bottle before storing it.

Spot Cleaning Walls and Furnishings

Materials

Detergent solution in a plastic spray bottle
Creme- or lotion-type cleanser
Clean water in a plastic spray bottle
Clean cloths and/or sponges
Measuring device

Areas Where Applicable

Non-fabric, above-floor surfaces that are frequently touched require spot cleaning most often. Areas around wall switches, elevator buttons, push plates on doors, and wall areas near telephones require frequent spot cleaning. Furnishings such as desks, tables, chairs, and telephones require routine spot cleaning.

Preparation of Materials

Dampen a cloth or sponge with clear water and wring it as dry as possible. If a properly diluted detergent solution is not already available in a spray bottle, mix the solution. Fill the spray bottle about ¾-full of water and add the appropriate amount of detergent. Remember, dilution directions on most detergents are given in ounces of concentrate per gallon of water. The spray bottle normally holds between ⅛ and ¼ of a gallon and the amount of concentrate used must be measured accordingly.

Instructions

1. If the soiled area is non-electrical, spray the area with a small amount of detergent solution and wipe with a damp cloth.
2. Never spray solution directly onto a switch, elevator call button, or other electrical device. Instead, spray a small amount of solution onto a damp cloth and use the cloth to clean the soiled area.
3. For stubborn wall stains, it may be necessary to use the creme- or lotion-type cleanser. Place a small amount of cleanser on a damp cloth or sponge and wipe the area. After cleaning, rinse the area with clean water. If non-electrical, spray it lightly with clean water and wipe dry. For electrical areas, spray clean water onto a clean cloth and rinse the area with this cloth. Lotion- or creme-type cleansers are slightly abrasive and can dull some finishes. Use only when absolutely necessary, and never use on finished wood or smooth plastic surfaces.

Cleanup

Rinse and wring dry all cloths and sponges. If the detergent solution remains in the spray bottle for future use, properly label the bottle before storing it.

Wall and Ceiling Washing

Materials

Detergent

Equipment

Method A:	Scaffolding or ladder 2 buckets 2 sponges (or soft cloths) Vacuum or triangular dust mop Large drop cloth (if needed)
Method B:	2 buckets Lightweight sponge mop Triangular dust mop or second sponge mop Sponges or cloths Large drop cloth (if needed)

Preparation of Materials

Make cleaner solution in warm water. Fill second pail with warm, clear rinse water. Change water frequently.

Preparation of the Area

Remove all furniture, pictures, and other objects from area to be cleaned. Remove all excess dust and cobwebs from ceiling and walls with vacuum or dust mop. Use bottom-to-top stroke to catch hanging cobwebs.

Instructions/Method A

1. Spread drop cloth to control spillages and move it as you progress.
2. Be sure ceiling is washable (metal or plaster). Begin at one corner of the ceiling. Sponge the cleaner-disinfectant solution onto an area about four feet square. Use a left-to-right stroke.
3. Squeeze cleaner-disinfectant sponge dry and pick up the cleaner-disinfectant solution.
4. Apply rinse sponge to the same area, then squeeze dry and pick up rinse water.
5. Continue across ceiling in this manner until finished.
6. Begin at the bottom of the wall and work toward the top, following the same washing and rinsing technique used on the ceiling. Try not to let the solution run down the wall.
7. Wash adjacent woodwork and baseboards using above methods.
8. When possible, two workers should wash walls as a team—one doing the lower half, the other following with the upper half.

Instructions/Method B

1. Prepare materials and the areas as in Method A.
2. Dip sponge mop in cleaner solution and squeeze it until it is wet but not dripping.
3. Wet the ceiling or wall area to be cleaned. Work from the top down with this method. To remove marks or heavily soiled spots, squeeze the mop and touch it to scouring paste. Then rub the soiled area carefully.
4. Rinse the area with the triangular dust mop or second sponge mop wet in clear rinse water. Wring the mop by hand or by pressing it before applying to wall or ceiling.
5. When cleaning or rinsing walls, be careful not to wet acoustical ceilings. Clean the wall area near the ceiling with a hand sponge.
6. Wash adjacent woodwork and baseboards using sponges.
7. When possible, two workers should wash walls as a team—one washing, the other rinsing.

Cleanup

Clean all equipment and return to maintenance storage areas.

Cleaning Water Fountains

Materials

Cleaner disinfectant in a plastic spray bottle
Lotion-type cleanser
Metal polish
Supply of clean cloths or sponges
Percolator brush
Rubber gloves

Areas Where Applicable

All porcelain and metal water fountains, either free-standing or built-in.

Preparation of Materials

Prepare a cleaner disinfectant solution in a plastic spray bottle according to the dilution instructions printed on the manufacturer's container. Dampen a sponge or cloth with cleaner disinfectant solution. Always wear rubber gloves when using disinfectant chemicals, since these chemicals may irritate the skin.

Instructions

1. Spray cleaner disinfectant on all top surfaces of the drinking fountain. Then wipe surfaces with a sponge dampened with cleaner disinfectant. Make sure the sponge is used *only* for drinking fountains and not in the rest room procedure.

2. If the basin of the drinking fountain is stainless steel, wipe this area with a clean, dry cloth to prevent water spotting.
3. Use a small amount of lotion cleanser on the sponge to remove soil and mineral buildup. A small amount of lotion cleanser may be placed on the end of a percolator brush to remove soil and mineral deposits in the drain area and around the base of spigots and faucets. Rinse area with clear water and wipe dry.
4. Using a sponge dampened with cleaner disinfectant, wipe the sides and base of the drinking fountain. If sides are metal, use a metal polish to remove smudges and fingerprints.

Cleanup

Rinse and wring dry the cloths and sponges used. Properly label the spray bottle before storing it.

Cleaning Sinks and Wash Basins

Materials

Cleaner disinfectant
Lotion-or creme-type cleanser
Colored sponges
Clean, dry cloths
Plastic spray bottle
Rubber gloves
Small percolator brush

Areas Where Applicable

All rest room facilities, locker and athletic areas equipped with toilet facilities; classroom, medical, and laboratory areas where basins are provided for wash-up. Clean fixtures in these areas thoroughly and properly every day.

Preparation of Materials

If the cleaner disinfectant solution is not already mixed in a plastic spray bottle, prepare solution. During the normal rest room cleaning operation, a bucket of cleaner disinfectant solution will be used to mop the floor. The plastic spray bottle (and small plastic pail) can be filled from this bucket.

Preparation of the Area

Doors to the rest rooms should be propped open or locked, and a sign posted (or some other indication given) that cleaning is in progress and the rest room is not to be used.

Instructions

1. Normally, the first fixtures to be cleaned in a rest room are the basins. These should be cleaned *after* the mirrors, lights over the mirrors, towel cabinets, soap dispensers, and other items in the area of the basins.
2. Turn on the faucets to rinse the interior of the basin.
3. Close the drain to make sure that the sponge or cloth will not catch on the drain plug. Spray the basin liberally with cleaner disinfectant from the plastic spray bottle and wipe with a damp sponge. Wipe the hardware also.
4. Open the drain and spray cleaner disinfectant into it. Wipe the drain plug and the rim of the drain with the sponge or cloth. Periodically apply a small amount of lotion cleanser to a percolator brush to clean residue and mineral build-up in the drain area.
5. Spray some cleaner disinfectant into the overflow outlet. Turn on the water and rinse the bowl.
6. Wipe the hardware dry with a clean cloth or paper towel to prevent spotting.
7. Wipe skirts or sides of the basin with a damp cloth or sponge. If heavily soiled, spray sides with cleaner disinfectant before wiping.
8. The bottoms of sinks and basins and the pipes and valves under them normally do not need to be cleaned every time the basin is cleaned. However, do not neglect these areas. Wipe them with a sponge dampened with a cleaner disinfectant approximately once every five or six times the basins or sinks are cleaned.
9. If a build-up of soap, rust, or mineral residue is apparent in the bowl of the sink or basin, use a small amount of lotion or creme cleanser on a dampened sponge to remove. Caution should be exercised when using lotion or creme cleanser, especially on stainless steel or terrazzo constructed wash basins. Stainless steel basins will become dull and the seal coating on terrazzo basins removed if creme cleanser is used too often or rubbed too vigorously during cleaning.

Restrictions on Use of the Area

If only the fixtures are being cleaned, as may be the case with wash-up basins in a classroom or laboratory area, there are no restrictions. In a rest room however, no traffic should be allowed until all rest room cleaning is completed.

Cleanup

Rinse all sponges and cloths. Wring the sponges and cloths as dry as possible and store them so that they will not become soiled or used for other rest room fixtures. If the cleaner disinfectant solution is to be left in the plastic spray bottle for later use, properly label the bottle before storing it.

Cleaning Commodes

Materials

Cleaner disinfectant
Acid-type bowl cleaner
Colored sponges
Clean, dry cloths
Bowl mop
Plastic spray bottle
Rubber gloves
Small plastic pail (optional)

Areas Where Applicable

All rest room facilities, locker and athletic areas equipped with toilet facilities. Clean fixtures in these areas thoroughly and properly every day.

Preparation of Materials

If the cleaner disinfectant solution is not already mixed in a plastic spray bottle, prepare the solution. During the normal rest room cleaning operation, a bucket of cleaner disinfectant solution will be used to mop the floor. The plastic spray bottle (and small plastic pail) can be filled from this bucket.

Preparation of the Area

The door to the rest room should be propped open or locked, and a sign posted (or some other indication given) that cleaning is in progress and the rest room is not to be used.

Instructions

1. In most rest room cleaning operations, the fixtures that are cleaned *after* the basins are the commodes and the partitions. Begin the cleaning by flushing the fixtures.
2. Spray the top of the toilet set with a liberal amount of cleaner disinfectant solution and wipe it thoroughly with a damp sponge (or dip the sponge in the pail of cleaner disinfectant and wipe the seat).
3. Wipe the seat thoroughly dry with a clean cloth.
4. Raise the seat and spray the underside with cleaner disinfectant and wipe it with the damp sponge. It should also be dried with a clean cloth. Spray and wipe the entire exterior of the fixture.
5. Spray a liberal amount of cleaner disinfectant into the bowl. Using the bowl mop, thoroughly scrub all surfaces above the water level, paying particular attention to the underside of the flushing rim.
6. Flush the fixture and follow the water line as it decreases with the bowl mop, scrubbing in a circular motion. After the inside of the bowl has been

thoroughly cleaned, flush the fixture one more time to ensure that all chemicals have been removed from the surface.

7. Because of buildup, due mainly to minerals in the water, it may be necessary to occasionally use an acid-type bowl cleaner to clean the interior of the commode. Extreme care should be taken when using this product. If an acid-type bowl cleaner comes in contact with skin or eyes, immediately flush with clean water. To use the acid-type bowl cleaner, first wet the bowl mop and then pour the bowl cleaner onto the mop. Always hold the mop over the bowl while applying acidic cleaner.
8. Scrub vigorously under the flushing ring and at the water level to remove all buildup, rust, and scale. Flush the fixture and follow the water level down with the bowl mop, vigorously scrubbing in a circular motion. Flush the fixture one more time to remove acid from all surfaces.
9. After cleaning each commode, damp wipe all pipes, valves, and connections.
10. Before leaving the stall, damp wipe all partitions, including the tops. Either spray with cleaner disinfectant and wipe with a damp sponge, or dip a sponge in a pail of cleaner disinfectant solution and wipe all surfaces of the partitions. Remove any writing or drawing on the partitions as thoroughly as possible.

Restrictions on Use of the Area

No traffic should be allowed until all rest room cleaning has been completed.

Cleanup

Spray bowl mop liberally with cleaner disinfectant solution and rinse it. Spray and rinse all sponges and cloths. Wring sponges and cloths as dry as possible and store so that they will be easily recognized by their color as equipment used only to clean rest room fixtures. If the cleaner disinfectant solution is to be left in the plastic spray bottle for later use, properly label the bottle before storing it.

Cleaning Urinals

Materials

Cleaner disinfectant
Acid-type bowl cleaner
Colored sponges
Clean, dry cloths
Bowl mop
Plastic spray bottle
Rubber gloves
Small plastic pail (optional)

Areas Where Applicable

All rest room facilities, locker and athletic areas equipped with toilet facilities. Clean the fixtures in these areas thoroughly and properly every day.

Preparation of Materials

If the cleaner disinfectant solution is not already mixed in a plastic spray bottle, prepare the solution. During the normal rest room cleaning operation, a bucket of cleaner disinfectant solution will be used to mop the floor. The plastic spray bottle (and small plastic pail) can be filled from this bucket.

Preparation of the Area

The door to the rest room should be propped open, or locked, and the sign posted (or some other indication given) that cleaning is in progress and the rest room is not to be used.

Instructions

1. After cleaning the commodes and partitions, urinals should be cleaned with a method similar to that used for commodes. First the fixture should be flushed and any waste that does not flush should be removed.
2. The wall areas above and beside the urinal should be sprayed with cleaner disinfectant and wiped with a damp sponge.
3. Spray and damp wipe all exterior surfaces of the urinal, including the base and areas underneath the urinal.
4. Spray the interior of the urinal with a liberal amount of cleaner disinfectant solution. Beginning at the top of the urinal, scrub thoroughly with the bowl mop, particularly the underside of the upper flushing rim.
5. Flush the fixture and follow the decreasing water level down with the bowl mop, scrubbing vigorously. Flush the fixture one final time to remove any remaining cleaning solution or residue.
6. It is periodically necessary to clean the urinals with an acid-type bowl cleaner. Begin by flushing the fixture and wetting the bowl mop. While holding the bowl mop over the urinal, pour the bowl cleaner onto the mop.
7. Scrub the interior of the urinal thoroughly with the mop and acid-type bowl cleaner, especially around the edges and under the upper flushing rim. Scrub until all build-up, rust, and scale is removed. Should the acid-type bowl cleaner come in contact with skin or eyes, flush immediately with clean water.
8. Flush the fixture and scrub the lower part with the bowl mop as the water level decreases. Flush the fixture one more time to remove any remaining acid.
9. If there are partitions between the urinals, spray partitions with cleaner disinfectant and wipe with a damp sponge (or wipe with a sponge soaked in cleaner disinfectant).

10. Pipes, valves, and other hardware connected to the urinal should be damp wiped with cleaner disinfectant and then wiped dry with a clean cloth or paper towel to prevent spotting.

Restrictions on Use of the Area

No traffic should be allowed until all rest room cleaning is complete.

Cleanup

Spray the bowl mop liberally with cleaner disinfectant solution and rinse it. Spray and rinse all sponges and cloths. Wring the sponges and cloths as dry as possible and store them so that they will be easily recognized by their color as equipment used only to clean rest room fixtures. If the cleaner disinfectant solution is to be left in the plastic spray bottle for later use, properly label the bottle before storing it.

Cleaning Tubs and Showers

Materials

Cleaner disinfectant
Lotion- or creme-type cleanser
Shower stall cleaner
Pump-up sprayer and/or plastic spray bottles
Sponge
Clean, dry cloths
Deck brush with handle
Squeegee with handle
Percolator brush
Rubber gloves

Areas Where Applicable

All shower and rest rooms in residence halls, locker rooms, and athletic areas. Clean the fixtures in these areas thoroughly and properly every day.

Preparation of Equipment and Material

If the cleaner disinfectant solution is not already mixed in a pump-up sprayer or spray bottle, prepare the solution. Shower stall cleaner should be mixed in a spray bottle each day.

Preparation of the Area

The door to the shower, locker, or rest room should be propped open or locked, a sign posted indicating that cleaning is in progress, and that the shower facilities are not to be used.

Instructions

1. Before cleaning, pick up all bits of soap from the shower or tub area. Remove hair and other material from the drain area.

2. Using a pump-up sprayer, completely cover all wall surfaces of the shower or tub area with cleaner disinfectant solution. A spray bottle may be used if the area to be cleaned is small or would not warrant preparing a large amount of cleaner disinfectant solution.
3. Agitate the cleaner disinfectant solution using a hand-held deck brush. (A deck brush with handle may be easier if a gang shower room is being cleaned). Use a sponge dampened with cleaner disinfectant to clean places that the deck brush won't reach, such as corners, soap dishes, chrome fixtures, etc. A small amount of lotion- or creme-type cleanser may be used to remove soap scum buildup in soap dishes.
4. Again, using the pump-up sprayer or spray bottle, completely cover the shower floor or tub with cleaner disinfectant solution. Agitate the solution using a deck brush. (In the case of a tub, use a damp sponge.)
5. Check the drain for mineral or scum buildup. If buildup is present, use a small amount of creme cleanser and a percolator brush to remove. If drains in shower rooms and locker rooms are not used for long periods, pour water into the drain to prevent sewer gas from backing up into the room.
6. About every fifth or sixth cleaning, or when a buildup of water minerals and soap scum becomes apparent, apply a shower stall cleaner to the walls and floors. Agitate the cleaner using a deck brush or sponge. Immediately rinse the walls and floors using clear water to prevent damage to tile grout. Do not use shower stall cleaner in tubs, but use a small amount of creme cleanser and a sponge to remove scum or mineral buildup. Read the directions for shower stall cleaner completely before using, since this product may damage some surfaces, such as aluminum.
7. Using a squeegee, remove all excess solution from walls and floor surfaces. Wipe all chrome fixtures with a clean, dry cloth to prevent spotting. If the shower or tub has a plastic or rubberized curtain, damp wipe this curtain using a sponge dampened in cleaner disinfectant solution.

Cleanup

Rinse all sponges and cloths. Wring the cloths and sponges as dry as possible and store for subsequent use in cleaning showers and tubs. If shower stall cleaner is used, thoroughly rinse all equipment in clear water, including spray bottles, deck brushes, sponges, and cloths.

Carpet Vacuuming

Materials

Commercial upright vacuum (with revolving brush and beater bar)
Pile lifter-type vacuum (with revolving brush powered by a separate motor)
Wide area carpet vacuum

Tank vacuum equipped with a wand and carpet tool
NOTE: All of these different vacuums may not be necessary for maintaining a particular area of carpet.

Areas Where Applicable

All carpeted floors require regular vacuuming.

Preparation of Materials

Dirt bags should be empty before any vacuuming is done.

Preparation of the Area

Unless only traffic patterns are being vacuumed, create as much open area as possible by moving items such as trash cans, chairs, and portable furniture.

Instructions

Carpet vacuuming can be divided into three basic processes: frequent vacuuming of traffic patterns using the standard upright vacuum, less frequent vacuuming of entire carpeted areas using the standard upright carpet vacuum as well as hard-to-reach places using the tank vacuum, and the infrequent vacuuming of open areas using the pile lifter-type vacuum. The exact frequencies for each of these techniques depends on the soil level of the area and the level of care desired. The wide area carpet vacuum is used in place of the standard upright carpet vacuum when the operator can save time and effort in an open area.

1. When using the standard upright carpet vacuum to clean traffic areas, begin at one end of the carpet and follow the traffic pattern to the other end or as far as the electrical cord permits without stretching. Then return alongside and slightly overlap the edge of each previous pass. This pattern should be repeated two or three times for heavily soiled areas.
2. When vacuuming the entire carpeted area is desired, the standard upright carpet vacuum should be used in the pattern described above for the entire area. The tank-type vacuum with wand and carpet tool is used in areas that are inaccessible to the upright machine. Sometimes light soil from hard-to-reach areas may be brushed into open areas with a broom or stiff brush.
3. When the pile lifter-type vacuum is used, the same pattern should be followed.
4. Follow the frequencies established for each type of vacuuming. Excessive use of the more powerful pile lifter-type vacuum may cause damage to the carpet by loosening tufts from the backing or by pulling the carpet loose from the floors and tack-strips. Precisely adjusting the pile lifter-type vacuum is also critical.

5. The dirt bag on any vacuum should not be allowed to fill more than half way. It should be checked and emptied often. When emptying the bag, avoid spreading dust.

Cleanup

Empty all dirt bags. Wipe dust from the machine and the cord with a clean cloth. Wind the cord properly around the hooks provided on the machine and store the machine in the proper position.

Spot Cleaning Carpets

Materials

Shampoo solution in a plastic spray bottle
Gong brush with stiff synthetic bristles
Stain removal kit
Water extraction unit
Supply of clean cloths
Aerosol can of compressed gas
Putty knife

Areas Where Applicable

Almost any carpeted floor of synthetic fiber pile.

Preparation of Materials

Prepare a shampoo solution in the plastic spray bottle according to the manufacturer's dilution instructions printed on the container.

Instructions

1. Before attempting to spot clean liquid spills, absorb as much of the liquid from the carpet as possible using cloths, paper towels, or a clean sponge.
2. Apply shampoo solution from a spray bottle directly on the spot. Avoid wetting the carpet too much.
3. Work from the outside of the spot to the center with a stiff-bristled gong brush. This prevents spreading the spot over a larger area.
4. Blot the shampoo solution from the carpet with clean cloths, paper towels, or a sponge. Repeat procedure several times, if necessary, or until the spot has disappeared.
5. If the carpet is stained and the material unknown, a stain removal kit may be used. Only designated individuals who are thoroughly familiar with the use of volatile solvents and chemicals should attempt to remove carpet stains using a stain removal kit.
6. For large area spills, a water extraction vacuum may be used. Refer to the procedure concerning water extraction for instructions on the proper use of this equipment.

7. Gum or tar-like substances can be removed using compressed gas in an aerosol can and a putty knife. Freeze the substance by spraying the compressed gas directly on the material. Then lift the material from the carpet fibers using a putty knife.
8. After removing stains from carpets, allow the area to dry and then vacuum to restore the pile to its original condition.

Cleanup

Rinse and wring dry cloths and sponges. Properly label the spray bottle of shampoo solution before storing it.

Dust Mopping

Materials

Dust mop assembly
Dust mop head
Counter brush
Dust pan
Hand scraper (putty knife)
NOTE: The size of the dust mop will depend on the area in which it is used. An 18- to 24-inch size is usually best for offices and other congested areas, while a 36-inch or wider mop may be used in corridors, gym floors, or other large open areas.

Areas Where Applicable

Any smooth, non-carpeted floor that is not wet or heavily soiled may be dust mopped. Rough floors such as brick, unsealed concrete, or stone should not be dust mopped.

Preparation of the Area

Wet or heavy soil should be removed by sweeping before dust mopping.

Instructions

1. For open areas, place the dust mop next to the wall and push it in a straight line as far as possible.
2. If light objects such as trash cans are encountered, hold the mop in place with one hand and move the object aside with the other. Push the mop over the area where the object was and then replace the object.
3. At the end of each pass, turn the dust mop without lifting it from the floor and return, overlapping the previous pass by one or two inches. Continue this pattern until the entire area is dust mopped or visible soil begins to accumulate on the front side of the dust mop.
4. For small congested areas, such as small offices, begin at the door or entrance to the area and push the mop around the outside of the area. It

is usually best to follow a counter-clockwise pattern with the last pass sweeping the center of the area and moving back out the door.

5. After an area has been dust mopped, or when visible soil appears to collect on the mop, the soil must be collected and the mop head cleaned. To remove the soil that does not adhere to the mop carefully lift the mop head off the floor and lean the mop against the waste receptable. Be careful not to let the mop head touch walls, furniture, or other building surfaces. Brush the soil into a dust pan with a counter brush. Dump the soil into a waste container holding the pan as low as possible to prevent spreading dust.
6. There are three ways in which the soil may be removed from the dust mop head: vacuuming the head, brushing the head over a waste receptacle, and placing the head in a plastic waste bag and shaking it. Each of these methods yields adequate results and the one used should depend on the location. If a vacuum cleaner is easily accessible, it may be used to vacuum the mop head. If plastic trash can liners are used, enclose the mop head and shake it. If these methods are not available, brush the mop head carefully with a counter brush while holding it as low as possible over or in the waste container.
7. If gum or other sticky soil is encountered while dust mopping, remove it with the hand scraper.

Cleanup

Remove the dust mop head from the mop assembly and place it in the proper receptacle. If it is to be laundered and treated on the premises or collected and replaced by a dust mop service, it should be placed at the proper collection point. If the dust mop head is disposable and of no further use, place it in the waste receptacle. The dust mop assembly should be properly hung in a tool holder. Wipe the dust pan and hand scraper clean.

Manual Sweeping

Materials

Push broom (24") with handle that reaches approximately eye level when the broom is resting on the floor with handle straight up
Counter brush
Hand scraper (putty knife)
Dust pan
Waste container

Areas Where Applicable

Smooth floors that are wet or heavily soiled—usually around entrances, heavily used lobbies, vending and dining areas.

Preparation of Materials

Check broom handle to see that it is properly and securely fitted into the brush.

Preparation of the Area

Create as much open area as possible by moving items such as lightweight chairs in vending and dining areas.

Instructions

1. Beginning in a corner, place the broom flush against the baseboard and pull the soil approximately three feet away from the wall.
2. Go around all walls of small areas or approximately 20 to 30 feet of both walls of a long corridor.
3. After the soil has been pulled away from walls and congested areas, push it to a convenient central point for collection.
4. Push the soil with strokes of 2 to 4 feet. Strokes that are too short require excessive effort, while strokes that are too long make it difficult to control the soil.
5. Use the hand scraper to loosen gum or other sticky soil.
6. Push the soil onto the dust pan with a counter brush.
7. Dump the soil into a waste container. Hold the dust pan deep in the container when dumping it to avoid spreading dust.
8. If no further cleaning is to follow, replace items moved.

Cleanup

Return all equipment to the proper storage area. Wipe the dust pan and hand scraper clean. Hang broom and counter brush in the proper tool holder.

Spot Mopping

Materials

Detergent or cleaner disinfectant
Mop bucket with wheels, 44-quart capacity
Wringer
Mop handle, reaching from the floor to approximately eye level of the user
"Wet Floor—Caution" signs, if this warning is not printed on the mop bucket
Hand scraper (putty knife)
Hand scouring pad (*not steel wool*)
Measuring device

Areas Where Applicable

Non-carpeted floors that are subject to soiling from sources other than traffic. Lounges, dining areas, and laboratories that are frequently soiled by spills are examples of this type of area. Spot mopping may also be used where isolated soil occurs from leaks in equipment such as water fountains, radiators, vending machines, etc.

Preparation of Materials

Properly attach the mop head to the handle. Fill the mop bucket approximately half-full of clean, hot water. Add 4 ounces of detergent for each gallon of water or add ½ ounce or one premeasured package of cleaner disinfectant for each gallon of water. A 44-quart bucket half-filled contains approximately 5 gallons. NOTE: Always put the water into the bucket before adding the detergent or cleaner disinfectant. Do not use too much detergent or cleaner disinfectant. To do so is wasteful, can weaken the floor finish, and can cause a film or buildup on the floor that makes it more difficult to clean next time.

Preparation of the Area

Loose soil should be removed by sweeping or dust mopping before spot mopping.

Instructions

1. Dip the mop into the solution and agitate it gently in order to mix the solution and saturate the mop head.
2. Place the mop head in the wringer and wring it nearly dry.
3. Mop the soiled area until all visible soil is removed.
4. Stains and scuffs that are not removed by normal mopping should be rubbed with the heel of the mop. If this method is not effective, the hand scraper or scouring pad should be used.
5. After each spot of obvious soil has been cleaned, dip, agitate, and wring the mop and move to the next soiled area.

Restrictions on Use of the Area

Avoid walking directly on those spots that have been mopped until the floor is completely dry.

Cleanup

Rinse the mop head and the scouring pad thoroughly. Wring the mop as dry as possible and hang it in a proper tool holder, head down, but with strings off the floor. Wash the wringers and the buckets, inside and outside. Wipe the hand scraper clean.

Damp Mopping

Materials

- Detergent or cleaner disinfectant
- Mop bucket with wheels, 44-quart capacity
- Wringer
- Measuring device
- Mop handle reaching from the floor to approximately eye level of the user
- Cotton mop head, 24-ounce (a lighter or heavier mop head may be used if it better suits the physical characteristics of the user)
- "Wet Floor—Caution" signs, if this warning is not printed on the mop bucket
- Hand scraper
- Hand scouring pad (*not steel wool*)

Areas Where Applicable

Non-carpeted floors that have been soiled by gneneral traffic but are not dirty enough to require wet mopping. Corridors, exhibit areas, and lobbies are examples of areas that require damp mopping as a part of a routine floor care program.

Preparation of Materials

Properly attach the mop head to the handle. Fill the bucket approximately half-full with clean hot water. Add the proper amount of detergent for each gallon of water or one pre-measured package of cleaner disinfectant for each gallon of water. A 44-quart bucket half filled contains approximately 5 gallons.

Preparation of the Area

Loose soil should be removed by sweeping or dusting before damp mopping.

Instructions

1. Place the "Wet Floor—Caution" signs at the edges or entrances of the area.
2. Dip the mop into the solution and agitate it gently in order to mix the solution and saturate the mop head.
3. Place the mop head in the wringer and wring the mop nearly dry.
4. Use a figure eight stroke to mop all open areas, particularly traffic patterns. Turn the mop over after every four or five strokes. Re-soak and wring the mop whenever it collects a noticeable amount of soil.
5. Stains and scuffs that are not removed through the normal mopping action should be rubbed with the heel of the mop. If this method is not effective, use the hand scraper or scouring pad.

6. Change the solution in the bucket when it becomes too dirty to be an effective cleaning agent.

Restrictions on Use of the Area

Traffic should not be allowed in the area until the floor is completely dry.

Cleanup

Rinse the mop head and scouring pad thoroughly. Wring the mop as dry as possible and hang it in the proper tool holder, head down, but with the strings off the floor. Wash the wringer and the bucket inside and outside. Wipe the hand scraper clean.

Wet Mopping

Materials

Detergent or cleaner disinfectant
Two mop buckets with wheels, 44-quart capacity
Two wringers
Mop handle, reaching from the floor to approximately eye level of the user
Cotton mop head, 24-ounce (a lighter or heavier mop head may be used if it better suits the physical characteristics of the user)
"Wet Floor—Caution" signs, if this warning is not printed on the mop buckets
Hand scraper
Hand scouring pad (*not steel wool*)
Measuring device

Areas Where Applicable

Almost all non-carpeted floors require wet mopping at some time. Entrances, vending and dining areas, medical and biological wet labs, and rest rooms must be wet mopped frequently. Pedestal-type floors in computer areas, cork floors, wooden floors that are not sealed, and badly worn linoleum floors should never be wet mopped.

Preparation of Materials

Properly attach the mop head to the handle. Fill each bucket approximately half-full of clean, hot water. Add to one bucket the proper amount of detergent or cleaner disinfectant for each gallon of water or add one premeasured package of cleaner disinfectant for each gallon of water. A 44-quart bucket half filled contains approximately 5 gallons.

Preparation of the Area

Create as much open area as possible by moving items such as trash cans, chairs, and portable furniture. Loose soil should be removed by sweeping or dust mopping before wet mopping.

Instructions

1. Place the "Wet Floor—Caution" signs at the edges or entrances of the area.
2. Dip the mop into the solution bucket and agitate it gently in order to mix the solution and saturate the mop head.
3. Place the mop head in the wringer and press down on the mop handle until the solution quits dripping from the mop head.
4. Beginning in a corner of the area to be mopped, place the mop head as near the baseboard as possible without actually touching it. Pull the mop along the edges of congested areas until an area of about 200 square feet has been "striped." If too large an area is mopped at one time, the solution will dry before it can be rinsed.
5. Place the mop in the rinse bucket, agitate it, and wring it dry. Then place it back in the solution bucket and press it in the wringer until it quits dripping. When wet mopping, never move the mop directly from the floor into the solution bucket.
6. Carefully apply solution to hard-to-reach areas. Then use a figure-eight stroke to spread solution onto the open area, just overlapping the "striping" around the edges. Turn the mop over after every four or five strokes. Rinse, wring, and re-soak the mop whenever it appears to be spreading soil or whenever it does not appear to be leaving enough solution on the floor.
7. Stains and scuffs should be removed by rubbing with the heel of the mop. If this method is not effective, use the hand scraper or scouring pad.
8. Change the solution and rinse water whenever they become dirty.
9. After the area has been wet with solution, rinse the mop and wring it nearly dry. Following the same pattern in which the solution was put down, pick it up with the mop. Rinse and wring the mop frequently. Change the rinse water as it collects soil.
10. If an area is large enough to require mopping in sections, overlap each previously mopped section by about one foot.

Restrictions on Use of the Area

After an area has been mopped, do not remove "Wet Floor—Caution" signs, replace furniture, or allow traffic in the area until the floor is completely dry.

Cleanup

Rinse the mop head and the scouring pad thoroughly. Wring the mop as dry as possible and hang it in a proper tool holder, head down, but with the strings off the floor. Wash the wringers and buckets, inside and outside. Wipe the hand scraper clean.

Automatic Scrubbing

Materials

Detergent or cleaner disinfectant
Auto scrubber
Mop bucket with wheels, 44-quart capacity
Wringer
Mop handle, reaching from the floor to approximately eye level of the user
Cotton mop head, 24-ounce (a lighter or heavier mop head may be used if it better suits the physical characteristics of the user)
"Wet Floor—Caution" signs, if this warning is not printed on the mop bucket
Hand scraper
Hand scouring pad (*not steel wool*)
Measuring device

Areas Where Applicable

Any non-carpeted floors except pedestal floors in computer areas, cork floors, unsealed wooden floors, and badly worn linoleum floors may be cleaned with an automatic scrubber. However, it takes time to prepare and put away the machine and it is difficult to maneuver in congested areas. For these reasons, the auto scrubber is most effective in large, open areas. Large lobbies, gallery and exhibit areas, and long corridors are areas where an automatic scrubber can be most effective.

Preparation of Materials

Check the squeegee to see that it is properly attached and does not have any cuts or breaks. See that the valves for emptying the solution and pick-up tanks are properly closed. Fill the solution tank with plain hot water. Add the proper amount of detergent or cleaner disinfectant to the solution tank. NOTE: Always put the water in the solution tank before adding detergent or cleaner disinfectant.

Preparation of the Area

Create as much open area as possible by removing such items as trash cans, chairs, and portable furniture. Loose soil should be removed by sweeping or dust mopping before scrubbing.

Instructions

1. Place the "Wet Floor—Caution" signs at the edges or entrances of the area.
2. Move the machine into a far corner of the area to be scrubbed. Always keep the brushes and squeegee in the up position when the machine is being moved and is not scrubbing. Plan a pattern that allows the longest passes and requires the fewest turns.
3. Lower the brushes and the squeegee, turn on the solution, and begin scrubbing along a wall or edge of the area. Scrub close to walls, but remember it is better to leave a small area unscrubbed than to risk damaging the wall or the machine.
4. Continue scrubbing in as straight a line as possible to the end of the area. Approximately 6 feet before the end of each pass, the solution should be turned off. The machine should be turned as quickly as possible and the solution turned back on at the end of the turn. Scrub parallel to the previous pass, overlapping it by 1 to 3 inches.
5. Continue this back-and-forth pattern until all open area is scrubbed.
6. Even with an effective squeegee and vacuum system, it is impossible to get up all the solution. After an area has been scrubbed, any remaining spots of water may be picked up with a mop and wrung into the bucket. Sometimes it is possible to place the mop head on a towel on top of the scrubber with the mop handle pointed safely away from the operator or passers-by. Then, any puddles left by the machine may be picked up by the operator as he goes along and wrung into the mop bucket when his scrubbing pattern brings him conveniently near it.
7. Some areas are too large to be scrubbed with one tank of solution. Whenever the worker refills the solution tank, he or she should empty the pickup tank.

Restrictions on Use of the Area

After an area has been scrubbed, do not remove "Wet Floor—Caution" signs, replace furniture, or allow traffic in the area until all spots of water have been dried with the mop.

Cleanup

Drain both the solution and pickup tanks of the scrubber and flush each tank thoroughly with clean, hot water. Rinse the brushes, brush cover, and squeegee. Wipe the squeegee and exterior of the machine with a clean cloth. Rinse the mop head thoroughly, wring as dry as possible, and hang in the proper tool holder, head down, but with the strings off the floor. Wash the wringer and the bucket inside and outside.

Spray Buffing

Materials

Suitable polymer floor finish
Detergent
Single-disc floor machine
Thick spray-buffing pad (open weave)
Driving block or pad holder
Pistol-grip spray bottle (or spray-buffing machine attachment)
Hand scouring pad *(not steel wool)*
Measuring device

Areas Where Applicable

Any floor coated with a synthetic polymer floor finish specifically developed for spray-buffing (or any polymer floor finish that tests show holds up under spray-buffing) can be spray-buffed. However, spray-buffing is less successful in heavily soiled, uneven, or extremely congested floor areas. Traffic patterns, places under desks and tables where people rub their feet on the floor, and areas just inside doors where people turn after entering a room or building are areas where spray-buffing can be particularly helpful.

Preparation of Materials

Be sure the electric cord on the floor machine is in good condition. Gently lean the machine back on the handle, check the driving block for proper installation and condition, and center the buffing pad on the driving block. Prepare the spray-buff solution by mixing one part synthetic polymer floor finish to one part water. If detergent solution is desired, add no more than 2 ounces of detergent to each gallon of spray-buff solution. Remember, the more detergent used, the more of the original floor finish will be removed with each spray-buffing. Pour the spray-buff solution into the spray bottle or the machine attachment. Spray some solution into an empty bucket or sink and adjust the nozzle until a proper spray pattern is achieved.

Preparation of the Area

Remove as much soil as possible by sweeping, dust mopping, spot mopping, or damp mopping before spray-buffing. If possible, move tables, desks, and other pieces of furniture that may obstruct worn areas.

Instructions

1. Begin spray-buffing by spraying a small amount of the solution onto the floor in front of the floor machine. Avoid spraying too much solution onto the floor as the pad will become wet and begin to grab.

2. Buff back and forth across the area that has been sprayed allowing each arc to overlap the previous one by approximately one-half the width of the pad.
3. Repeating these steps, work forward until the entire area has been spray-buffed.
4. Do not spray solution onto areas that cannot be buffed because they are too close to a wall or other obstruction. Do not spray solution onto parts of the floor where people do not walk. Spraying onto these areas will cause an undesirable buildup of floor finish, and will cause the floor to require stripping sooner than otherwise necessary.
5. When stains or scuffs are not removed by normal spray-buffing, spray the spot with spray-buff solution and rub it with a small scouring pad. Before the solution dries, buff the spot with the floor machine until the stain is removed and the appearance of the floor restored.
6. After an area has been spray-buffed, dust mop the floor completely to remove floor finish dust that may have been generated during the spray-buffing process.

Cleanup

Pour the remaining spray-buff solution from the spray bottle into a clean, closed-top container. Rinse the inside of the spray bottle and fill it with warm water. Spray this water in order to clean the nozzle. Remove the pad, brush it with another piece of spray-buff pad, and wash it out under cold water. Wipe the cord and exterior of the machine with a clean cloth. Store the machine in the proper position with the cord properly wound around the handles or hooks provided on the machine.

Dry-foam Carpet Shampooing

Materials

Dry-foam carpet shampoo
Carpet spot cleaning solutions

Equipment

Pile-lifter type vacuum
Dry foam carpet shampoo machine
Plastic pail
Funnel
Measuring device
Scrub brush
NOTE: When shampooing carpets, have a wet vacuum available in case spills or malfunctions of the machine put excessive amounts of solution onto the carpet.

Areas Where Applicable

Almost any carpeted floor can be cleaned using the dry foam method.

Preparation of Equipment

The dirt bag on the pile-lifter type vacuum should be checked and emptied or replaced if needed.

Preparation of Materials

Using the plastic pail and the measuring device, prepare the shampoo solution following the directions on the container. Using the funnel, carefully pour the solution into the tank of the carpet shampoo machine.

Preparation of the Area

Remove as much furniture from the area as possible. Treat stained areas with spot cleaning solution. Thoroughly vacuum the entire area with the pile-lifter type vacuum. Areas that cannot be reached with the vacuum, such as corners, should be brushed with the dry scrub brush or other stiff brush to bring loose soil into an area that can be reached with the vacuum.

Instructions

1. Be sure that shoes are clean or wear clean, rubber overshoes when shampooing carpet.
2. Before turning on the shampoo machine, follow the manufacturer's directions for adjusting the height of the brushes to be compatible with the pile of the carpet. If the brushes are too high, they will not clean properly. If the brushes are too low, there will be excessive wear on the carpet and unnecessary strain on the machine.
3. Begin scrubbing next to a wall or an edge of the carpeted area. Adjust the foam control and pace the motion of the machine so that sufficient but not excessive foam is applied to the carpet.
4. Move the machine forward as far as possible in a straight line. Then move the machine backwards over the same area.
5. At the end of each forward and backward pass, move the machine to one side and repeat this pattern on an adjacent area. The level of soil in the carpet determines degree of overlap. If the carpet is heavily soiled, it may be necessary to overlap half of each previous pass for effective cleaning. In lightly soiled areas, an overlap of 1 to 2 inches may be sufficient. In cases of an extremely soiled carpet, it may be necessary to shampoo twice. The second shampooing should follow a pattern at right angles to that of the first shampooing.
6. Corners and other areas that are not accessible to the machine may be cleaned by taking some of the foam generated by the machine and applying it manually with the scrub brush.

7. Follow the manufacturer's directions for draining any excess solution from the machine. This should be done in a non-carpeted area in case of spills.
8. After allowing about one hour to dry, vacuum the entire area with the pile-lifter vacuum. Make long, straight passes with the machine. After each forward pass, pull the machine backward over the same area to remove any footprints or wheel tracks.

Restrictions on Use of the Area

Allow plenty of time for the carpet to dry before it is subjected to heavy traffic. Drying time will vary considerably depending on temperature and humidity. When replacing the furniture in the area, place small pieces of plastic underneath legs or other parts of furniture that come in contact with the carpet. This will prevent stains from rust and dyes that may occur if carpet is still damp.

Cleanup

Empty and/or replace the dirt bag in the pile-lifter type vacuum. Wipe the exterior of the vacuum, including the cord, with a clean cloth. Rinse out the solution tank on the shampoo machine. Using a scrub brush and a cloth, remove all pile lint, foam, and dirt from the brushes of the shampoo machine. Wrap the cord properly around the hooks provided on the machine and store the machine in its proper position. Rise out the plastic pail, the funnel, and the measuring device.

Carpet Cleaning, Water Extraction Method

Materials

Anti-foam emulsion
Carpet shampoo specifically designed to be used with a water extraction system (to be used only on carpets that have never or seldom been shampooed).

Equipment

Pile-lifter type vacuum
Water extraction carpet cleaning outfit

Areas Where Applicable

Almost any carpeted floor may be cleaned using the water extraction process. Most often, this technique is used intermittently with dry-foam shampooing or some other carpet cleaning method. For example, if a carpeted area requires cleaning three times per year, it would be advisable to shampoo it twice and then use the water extraction method for the third cleaning.

Preparation of Equipment

If paper dirt bags are used in the carpet vacuum, a clean bag should be installed. If a permanent type bag is used, it should be emptied and replaced. The water extraction outfit should be assembled according to the manufacturer's directions. Some models may be hooked directly to a water source while others require that a tank on the machine be filled. Some manufacturers recommend the use of hot water with their equipment, others cold water, and others provide a heating element in the solution tank. Though hot water may react more quickly with shampoo residue in the carpet, generally cold water will provide adequate cleaning without risks of shrinkage, color bleeding, or damage to the carpet backing that may result from excessive use of hot water.

Preparation of Materials

Add the proper amount of carpet cleaner solution to the solution tank, *only* if the carpet has never or seldom been shampooed. (If the carpet has been shampooed three, four, or more times, there will be sufficient residue in the carpet for effective cleaning.) Add the proper amount of anti-foam emulsion to the recovery tank and follow any specific directions given by the manufacturer of the emulsion.

Preparation of the Area

Remove from the area trash cans, ash urns, and as much furniture as possible. Thoroughly vacuum the entire area with the pile-lifter vacuum. Isolated stains should be spot cleaned.

Instructions

1. Begin in corner of the area. Stand next to one wall while facing another wall. Stand far enough back so that a comfortable reach will place the spray vacuum head against the baseboard (usually about three feet away).
2. Activate the spray system while pulling the spray vacuum head away from the wall in a straight line.
3. Shut off the spray about 6 inches before the end of the stroke. If the spray vacuum head can be pushed easily, push it back to the wall, over the same path with the spray shut off. If the spray vacuum head cannot be pushed easily, but can only be pulled, lift it at the end of the stroke, return to the original spot where the pass began, and pull over the same area with the spray shut off. This technique gives each area a minimum of two passes: one with the spray and the vacuum, and one with the vacuum only.
4. After making the two passes described above, move the spray vacuum head and repeat the process.
5. The degree of overlap and the speed with which the spray vacuum head is moved on the carpet depends on the level of soil. Along walls and

baseboards, and other areas receiving little or no traffic, the machine can be moved quickly and with as little overlap as possible without leaving streaks. In heavily soiled areas or high traffic areas, the spray vacuum head should be moved more slowly and each pass should overlap the previous pass by about 50 percent.

6. The recovery tank should be watched and emptied whenever the foam gets within 2 or 3 inches of the top. If foam or water is allowed to enter the vacuum motor system, serious damage can result.
7. After the entire carpet has been cleaned, it should be allowed to dry approximately one-half hour and vacuumed with the pile-lifter type vacuum. When vacuuming a carpet after it has been wet cleaned, the final passes with the vacuum over each area should always be in the same direction.
8. When returning furniture and accessories to a carpeted area which has just been cleaned, pieces of plastic should be placed under the legs or any part which touches the carpet. The carpet may still be slightly damp and subject to stains from rust or dyes.

Restrictions on the Use of the Area

After the area has been vacuumed with a pile-lifter type vacuum, it is ready for traffic.

Cleanup

The recovery tank should be emptied. Any water remaining in the solution tank should be emptied or can be drawn into the recovery tank by placing the spray vacuum head or the vacuum hose into the solution tank and turning on the vacuum motor. Both the solution and recovery tanks should be rinsed and wiped dry. Rinse the vacuum hose, wand, and spray vacuum head by running clean water through them. All exterior surfaces of the machine, including the electrical cord, should be wiped dry with a clean cloth. The dirt bag of the pile-lifter vacuum should be emptied if it is a permanent type bag or replaced.

Scrubbing Floors

Materials

Neutral detergent

Equipment

Two mop buckets with wheels, 44-quart capacity
One (or two) wringers
Two mop handles, reaching from the floor to approximately eye level of the user

Two cotton mop heads, 24-ounce (a lighter or heavier mop head may be used if it better suits the physical characteristics of the user)
"Wet Floor—Caution" signs
Hand scraper (putty knife)
Hand scouring pad (*not steel wool*)
Measuring device

Areas Where Applicable

Any non-carpeted floors other than pedestal-type floors in computer areas, cork floors, unsealed wooden floors, and badly worn linoleum floors may be machine scrubbed. Rest rooms and locker rooms are frequently machine scrubbed.

Preparation of Equipment

Properly attach the mop heads to the handles. Fill one bucket approximately half-full of clean, hot water. Properly attach the driving block to the floor machine. Then attach and center the scrub brush or scrubbing pad.

Preparation of Materials

Add the proper amount of detergent for each gallon of water to the bucket of hot water.

Preparation of the Area

Create as much open area as possible by moving items such as trash cans, chairs, and portable furniture. Remove all loose soil by sweeping or dust mopping before scrubbing.

Instructions

1. Place the "Wet Floor—Caution" signs at the edges or entrances of the area.
2. Dip the mop into the solution and agitate it gently to mix the solution and saturate the mop head. Place the mop head in the wringer and press down gently. Apply solution to edges of the area by pulling the mop slowly along, but not quite touching, the baseboard.
3. After solution has been applied to the edges of the area, use a figure-eight stroke to apply solution to the open areas of the floor. *Do not flood the floor.* Turn the mop after every four or five strokes. Resoak the mop whenever it begins to leave too little solution on the floor.
4. Allow the solution to stand for three to four minutes.
5. Following the same pattern in which the solution was put down, go over the entire area with the floor machine overlapping each previous arc by approximately one-half the width of the scrubbing pad.

6. After scrubbing the area, use a dry mop to absorb the solution. After several passes with the mop, place the mop in the wringer of the second bucket and wring as dry as possible.
   NOTE: In larger areas, a wet/dry vacuum may be effectively used to pick up the dirty solution.
7. If the floor is heavily soiled, dump and rinse the solution bucket and fill it with clean water. Rinse one of the mops thoroughly. Rinse the floor by damp mopping it with this clean water.

Restrictions on Use of the Area

Do not remove "Wet Floor—Caution" signs, replace furniture or allow traffic in the area until the floor is completely dry.

Cleanup

Rinse the mop heads and the scouring pads thoroughly. Wring the mops as dry as possible and hang them in the proper tool holder, head down, with strings off the floor. Wash the wringers and buckets inside and out. Wipe the hand scraper clean. Remove the scrub brush or scrubbing pad from the floor machine and clean it thoroughly. Wipe the exterior of the floor machine and its cord with a clean cloth. Then store it in the correct position with the cord properly wound around the hooks on the machine. If a wet/dry vacuum was used, empty and rinse it thoroughly. Remember to rinse the hose, wand, and floor tool.

Stripping Waxed or Finished Floors

Materials

An appropriate floor stripping concentrate

Equipment

Two mop buckets with wheels, 44-quart capacity
Two wringers
Two mop handles, reaching from the floor to approximately eye level of the user
Two cotton mop heads, 24-ounce (a lighter or heavier mop head may be used if it better suits the physical characteristics of the user)
"Wet Floor—Caution" signs
Hand scraper (putty knife)
Hand scouring pad (not steel wool)
Measuring device
Single-disc floor machine with a stripping pad
Wet/dry vacuum

Areas Where Applicable

All floors coated with conventional water emulsion floor finishes or waxes.

Preparation of Equipment

Assemble all equipment in the area to be stripped. See that buckets, wringers, and mop heads are thoroughly clean. Properly attach the mop heads to the handles. Fill each bucket with about 5 gallons of clean, hot water.

Preparation of Materials

Add to one bucket the proper amount of stripper.

Preparation of the Area

All loose soil should be removed by thorough sweeping or dust mopping before stripping. Gum or sticky soil should be removed with the hand scraper or scouring pad. Remove as many pieces of furniture from the area as possible.

Instructions

1. Place "Wet Floor—Caution" signs at the edges or entrances of the area.
2. Dip the mop into the solution bucket and lay it gently in the wringer.
3. Beginning in a corner of the area, draw the mop slowly along, but not touching the baseboard. After the edges of the area have been "striped," apply stripper to the open areas of the floor using a figure-eight stroke with the mop.
4. Apply a liberal amount of solution to all areas, but *do not flood the floor.*
5. Allow the solution to stand for four or five minutes.
6. Beginning in a corner, use the floor machine with a stripping pad to go over the entire floor in overlapping arcs.
7. Pick up all solution with a wet/dry vacuum. If any areas appear to be drying before the solution is picked up with the vacuum, apply additional solution to these areas.
8. Using the clean mop, and following the pattern in which the solution was put down, apply clean water from the other bucket to the entire floor. Pick up the rinse water with a wet/dry vacuum.

NOTE: If a wet/dry vacuum is not available, solution and rinse water may be picked up with a mop, wringer, and bucket instead. When using this technique, it will be necessary to rinse the floor two or three times, rinsing the mop and changing the rinse water frequently.

Restrictions on Use of the Area

Do not remove "Wet Floor—Caution" signs, replace furniture, or allow traffic in the area until the new finish has been applied to the floor and allowed to dry.

Cleanup

Rinse the mop heads throroughly. Wring the mops as dry as possible and hang them in proper tool holders, head down, and with the strings off the floor. Wash the wringers and the buckets inside and outside. Empty and thoroughly rinse the wet/dry vacuum, including the hose, wand, and floor tool. Remove and thoroughly wash the stripping pad. Wipe the exteriors of the vacuum and the floor machine and the electrical cords with a clean cloth. Store the machines in the proper location with the cords properly wound around the hooks on the machine.

Applying Wax or Synthetic Floor Finish

Materials

Wax or floor finish

Equipment

Mop bucket with wheels, 44-quart capacity
Wringer
Mop handle, reaching from the floor to approximately eye level of the user
Fine strand, rayon mop head, 24-ounce (a lighter or heavier mop head may be used if it better suits the physical characteristics of the user)
"Wet Floor—Caution" signs

Areas Where Applicable

Wax or synthetic floor finish may successfully be applied to any resilient type floor and terrazzo.

Preparation of Equipment

Properly attach the mop head to the handle. Since absolute cleanliness of the mop head is essential, it is better to use a new mop that has been soaked overnight, washed in detergent solution, and thoroughly rinsed. The mop should not be allowed to dry completely, since a completely dry mop does not absorb certain types of floor finish quickly. Wash and thoroughly rinse the bucket and wringer.

Preparation of Materials

Pour a small amount of wax or finish into the bucket. Do *not return* any product that is not applied to the floor to the original container, since it will contaminate what is left. One gallon of product normally provides one coat for approximately 1,200 square feet. It is better to begin with too little and return for more than to have products that cannot be used.

Preparation of the Area

The floor should have been stripped, rinsed, allowed to dry thoroughly, and protected from any traffic before the finish is applied.

Instructions

1. Place the "Wet Floor—Caution" signs at the edges or entrances of the area.
2. Dip the mop into the floor finish until it is saturated. Then place the mop in the wringer and press until the mop does not drip when lifted out of the wringer.
3. Begin in a corner and pull the mop along without quite touching the baseboard.
4. After the baseboards and edges have been "striped," use a figure-eight stroke to apply a thin coat of finish to the remainder of the floor. Each time the mop is soaked with finish, press it in the wringer until excess finish is removed. No finish should drip from the mop when it is lifted out of the wringer, nor should an excessive amount of finish be put down when the mop is first placed on the floor
5. Allow the floor to dry at least one-half hour before applying a second coat of finish.
6. Apply a second coat of finish only to the open areas of the floor. Do not apply additional finish close to baseboards or other areas which obviously receive no traffic. Use the figure-eight stroke to apply the second coat. If the size and shape of the area permit, the pattern used to apply the second coat should be generally perpendicular to that used to apply the first coat.
7. After the second coat has dried, a third coat may be applied to high traffic areas.
   NOTE: Though good quality floor finishes dry to a good shine without buffing, some improvements will result if the new finish is buffed after drying about 48 hours.

Restrictions on Use

Do not remove "Wet Floor—Caution" signs, replace furniture, or allow traffic in the area until floor is completely dry (at least one hour after the application of the last coat). If the new finish is to be buffed to improve appearance, traffic should be limited until after the buffing.

Cleanup

Wash the mop head in detergent solution, rinse it thoroughly, wring it as dry as possible, and hang it in a proper tool holder head down and with the strings off the floor. The mop used for applying floor finish should be so designated in the storage area and not used in routine floor care. Dispose of floor finish remaining in the bucket and wash the bucket and wringer thoroughly.

Applying Solvent Sealer

Materials

Solvent sealer

Equipment

Lambswool duster
Application pan
"Wet Floor—Caution" signs

Areas Where Applicable

Solvent sealer is used on floors where rough surface and/or porosity would otherwise make maintenance with water emulsion finishes difficult. Concrete floors and wooden gym floors are the most common examples of solvent sealer use.

Preparation of Equipment

The applicator and pan must be completely clean.

Preparation of Materials

Fill the application pan approximately half-full of solvent sealer.

Preparation of the Area

The area should be properly stripped, allowed to thoroughly dry, and protected from traffic before it is sealed. The area should have adequate ventilation, and any instructions or cautions on the label of the container should be followed.

Instructions

1. Place the "Wet Floor—Caution" signs at the edges or entrances of the area.
2. Dip the mop into the seal pan, lift it just above the level of the liquid and press it against the side of the pan to squeeze out the excess product until it does not drip.
3. Beginning in a corner of the area, place the applicator as close as possible to the baseboard without touching it. Stand as far back from the baseboard as is comfortable and pull the applicator in a straight line away from the wall.
4. Lift the applicator and place it just far enough to one side of the previous pass so that it will meet but not overlap it.
5. Dip the applicator in the sealer as often as necessary to produce a light, even coat.
6. If there are expansion strips in the floor, use them as stopping points. This will prevent the appearance of lap marks in the finish.
7. Allow at least as much drying time as the manufacturer recommends and apply a second coat of sealer if desired.

Restrictions on Use of the Area

Do not remove "Wet Floor—Caution" signs, replace furniture, or allow traffic in the area until the floor is completely dry. Allow *at least* as much drying time as the manufacturer recommends.

Cleanup

Wash the applicator and the pan thoroughly with mineral spirits or other appropriate solvent recommended by the manufacturer of the sealer. Clean the applicator and the pan immediately after the work is completed.

7.8 CONCLUSION

Use available outside sources such as vendors and consultants, or visits to other institutions to get help and fresh ideas for managing custodial services. Custodial service programs will not stagnate if managers use innovative ideas to reduce problems and improve the operation. Managers must develop a program that works with the institution and the department's employees.

Individual creativity, user needs, and institutional politics define and determine custodial services. Many can give guidelines and advice, but only the manager of custodial services can give the institution the best possible program and service with the funds available.

Appendix 7-A

Custodial Service Levels

Modified Cleaning Routines and Frequencies for All Areas Encountered by Institution

Item	Frequency						
	Daily	Weekly	Monthly	4/Year	3/Year	2/Year	Yearly
Empty Waste containers	now	new-2/wk					
Sweep floors or vacuum carpet	now	new-2/wk					
Spot wet mop floors	now	new-2/wk					
Replace light bulbs	now	new-2/wk					
Clean chalkboard and trays	now	new-2/wk					
Damp wipe erasers	now-Eliminate						
Clean wash bowls and mirrors	now-Eliminate						
Dust furniture and window sills	now-Eliminate						
Clean chalkboard erasers		now-no					
Empty pencil sharpeners		now-Eliminate					
Dust doors, baseboards, ledges		now-Eliminate					
Thoroughly clean flooring & damp mop			now-Eliminate				
Buff floors			now-Eliminate				
Strip/wax floors (or on request)							now
Clean lights							now-new every 2 years
Dust blinds							now-Eliminate
Wash furniture							now-Eliminate
Wash windows							now-Eliminate

Appendix 7-B

Routine Cleaning
Academic Buildings

Schedule B Offices and Student Learning Areas

Area Types

- Art Rooms and Art Studios
- Auditoriums and Theaters
- Classrooms—Regular
- Classrooms—Tiered
- Computer Rooms
- Conference Rooms
- Drafting Rooms
- Gyms
- Laboratories—Teaching
- Library Stacks
- Lounges—Administration and Faculty
- Offices—Administration and Faculty
- Reading Rooms
- Seminar Rooms
- Stages
- Study Rooms
- Typing Rooms

Frequency	Task
Daily	Dry clean chalkboards and damp wipe chalk trays. Clean and replace erasers.
Daily	Empty waste and trash receptacles, ash trays, and pencil sharpeners. Spot clean receptacles.
Daily	Resupply paper products and soap dispensers.
Daily	*Clean and disinfect in-room drinking fountains.
Daily	*Clean and disinfect in-room wash basins and sinks. (This does *not* include laboratory-type sinks.)
Daily	Dust mop smooth and dry uncarpeted floors.
Daily	Sweep rough or wet uncarpeted floors.
Daily	Spot mop spills and lightly soiled uncarpeted floors.
Daily	Damp clean and disinfect exercise mats.
Daily	Spot clean spills and stains on carpeted floors.
Daily	Vacuum traffic patterns on carpeted floors.

Daily	Arrange furniture to its original position, and adjust thermostats to 68°F. Turn out lights if room is unoccupied.
Daily	Replace any burned out lights, and report any damage or vandalism to the supervisor.
Daily	Clean all assigned tools, equipment, and custodial rooms at end of each shift.
Twice a Week	Dust exposed horizontal surfaces of building, fixtures, and furnishings.
Twice a Week	Spot clean horizontal and vertical surfaces of buildings, fixtures, and furnishings. Remove graffiti.
Twice a Week	Spot clean interior glass surfaces including partitions, mirrors, and window glass.
Twice a Week	*Damp wipe telephone base and receiver.
Twice a Week	Clean and polish bright metal surfaces.
Twice a Week	*Damp clean those laboratory countertops and sinks that are clear.
Weekly or as Required	Completely damp mop or use an automatic scrubber on uncarpeted floors. For wood floors, only spot mop using a well-wrung mop head. Do *not* use an automatic scrubber or excessive amounts of water when cleaning wood floors.
Weekly	Spray buff floors coated with floor finish.
Weekly	Vacuum carpeted floors completely.
Monthly	Vacuum HVAC duct grills and register surfaces.
Monthly	Vacuum upholstered furniture, drapes, blinds, and shades.
As Required	Damp clean desk tops, table tops, and other working surfaces in offices if occupants have completely cleared the surface.
NOTES:	(*) Use a cleaner-disinfectant solution. Damp mop raised composition floors in computer areas with a well-wrung mop head. *Do not* bring mopping outfit into computer rooms. Spills may damage underfloor wiring and circuitry.

Powered equipment must *not* be used in computer tape storage areas and computer rooms unless first authorized by the appropriate department head or the supervisor.

In teaching laboratories clean only those countertops and sinks that the occupants have completely cleared. Use *only* a neutral detergent solution or lotion cleanser. *Do not* use ammonia, bleach, acids, or products containing these chemicals since severe injury could result. If uncertain about whether or not these surfaces may be cleaned safely, check with the supervisor.

Appendix 7-C

Custodial Inspection Form

Ratings
1. Unacceptable
2. Below Standard
3. Average/Standard
4. Superior

	Rating	Unsatisfactory Three-Day Check	Unsatisfactory Five-Day Check	Unsatisfactory Ten-Day Check	Factors	Unsatisfactory Items—List Specific Room	Notes
Hard Surface/Sweeping							
Soft Surface/Vacuuming							
Baseboards and Corners							
Buffing and Refinishing							
Steps							
Elevator Tracks							
Spotting and Mopping							
Drinking Fountains							
Window Sill							
Trim, Molding, Ledges							
Railings							
Glass and Mirrors							
Push and Kickplates							
Doors							
Wall Spotting							
Chalkboards and Trays							
Replacing Supplies							
Ashtrays, Receptacles							
Desk and Tabletops							
Trash Receptacles							
Furniture and Fixtures							
Vents, Lights							
Sinks							
Urinals							

Toilet Stools							
Partitions							
Equipment Care							
Supply Usage							
Closet Care							

Remarks:

Signature of Employee ______________________________

Date ______________________________

Appendix 7-D

Specification for Concentrated Neutral Detergent

Scope	This specification covers one grade of a liquid concentrated compound suitable for wet cleaning of both painted and unpainted surfaces where hard or soft water prevails.
Type	An effective cleaning agent for use on wood, rubber, asphalt tile, terrazzo, marble, concrete floors, and other surfaces.

Requirements:

1. Compound should be composed of synthetic organic detergents, sequestering, suspending, and other cleaning agents.
2. The ingredients should be assembled to form a homogeneous liquid with no more than a trace of suspended matter. It should be bio-degradable and mildly perfumed.
3. The compound should be non-caustic and contain no soap.
4. The compound should be completely soluble in distilled water at room temperature.
5. The compound should contain no free alkali or ammonia.
6. The compound should contain no free oil, abrasives, or other harmful ingredients and should not be irritating to the skin.
7. The compound should contain no more than 87 percent by weight of matter volatile at 105°C.
8. The compound should be stable and not lose its original effectiveness or otherwise deteriorate when stored for nine months in a closed shipping container at room temperature.

9. The synthetic organic detergent should be non-ionic or anionic, and formulated so it can be packaged in mild steel-type containers.
10. The pH of the compound should be no higher than 9.9 (Beckman pH meter) at a 1 percent concentration in distilled water.
11. Emulsification of grease, oil, and dirt must rate very good.
12. It must have excellent free rinsing properties.
13. The detergent should foam moderately and have excellent stability in the presence of grease and oil.
14. The undiluted concentrate should have a viscosity of not less than 450 cps. or more than 850 cps. at room temperature (20° C.).
15. The product may be diluted as much as one ounce per gallon (1:128) for application to cars and trucks: as much as 1 to 80 for cleaning windows, mirrors, and glassware; and as much as 1 to 50 for cleaning walls, woodwork, and all types of floors.
16. When used as directed, the product should be safe for use on all surfaces when used as directed.

Specifications for Quaternary Ammonium Germicidal Detergent

Scope	This specification covers one type of synthetic detergent and germicide compound designed for general cleaning and disinfecting in one operation.
Type	Liquid, quaternary ammonium compound.

Requirements:

1. *Chemical Properties* The product should be a blend of synthetic organic

detergents, inorganic alkaline builders, water softening agents, and synthetic quarternary ammonium germicide. The product should not contain any soap, mercury compounds, phenols, free chlorine, peroxide, formaldehyde, or materials that release such compounds when diluted according to directions. The germicidal agent should be a quaternary ammonium compound. The material shall be biodegradable.

2. *Antimicrobial Requirements* The product should have a minimum phenol coefficient of 10.0 against salmonella typhosa and staphylococcus aureous by the A.O.A.C. method. The product should pass the official A.O.A.C. use-dilution confirmation test at a 1 to 128 dilution. The product should kill pseudomonas aeruginosa at a 1 to 128 dilution and must be effective against both gram-positive and gram-negative organisms.
3. *Odor* A 1 to 128 dilution of the product in distilled water should be substantially odorless, and no odor should result from contact with surfaces cleaned.
4. *Hard Water Tolerance* The product should meet all other requirements of this specification in waters up to and including 750 parts per million of hardness.
5. *Cleaning Efficiency* A 1 to 128 dilution of the product should exhibit a cleaning efficiency of not less than 80 percent when tested as described in paragraph 4.4.6 of Federal Specification PC-431a. In solution the product should provide adequate, but not excessive, suds.
6. *Labeling* The affixed approved label should bear the Environmental Protection Agency (EPA) registration number confirming that the product conforms to EPA requirements for use in federally inspected

meat packing and poultry processing establishments, and as a non-misting steam. The product must be acceptable for use in medical and non-medical facilities. Each container of the product must bear a label that defines the contents, instructions for use, and any hazard warnings as prescribed by current Occupational Health and Safety Administration (OSHA) regulations.

7. *Volatility* The non-volatile content of the product when measured at 105°C should be 12.0 percent minimum by weight.

Appendix 7-E

Specification for High- and Low-solid Water Emulsion Metal-link Polymer Floor Finish

Scope This specification covers a self-polishing, slip resistant, all-synthetic water emulsion floor finish intended for use on—and not detrimental to—sealed or finished wood surfaces, asphalt tile, linoleum, rubber, vinyl composition, painted concrete, terrazzo, and cement surfaces. The product is to be used without dilution. Acid sensitive emulsions are excluded.

Requirements

1. The finish should consist of all synthetic components. It should contain no natural waxes.
2. The finish should contain a minumum of 15 percent non-volatile material when determined in accordance with ASTM method D-1289-64. For high solid floor finishes, the finish should contain a minumum of 23 percent non-volatile material.
3. The finish should consist of polyacrylic and polyethylene components. Polymers should be metal-linked to provide excellent detergent resistance.
4. The product should be safe for use on all kinds of floors including asphalt, vinyl, linoleum, terrazzo, marble, sealed wood, cork, rubber, and other composition tile surfaces.
5. The product should produce a colorless, non-slip, water resistant coating with a high gloss.

6. The finish should be recoatable within 30 minutes after the prior coat has dried. Second coat shall not whiten or lift the first coat and shall produce an enhanced gloss.
7. The product should resist scuffing, powdering, and scratching under traffic to a satisfactory degree and respond to buffing.
8. The finish should level well without streaking or puddling when applied with mop or lambswool applicator or when tested according to ASTM method D-1436-56.
9. The finish should resist wet cleaning with alkaline detergents without being removed from the floor and without destroying gloss. However, it should be readily removable by industrial and institutional wax strippers. Removability properties may be tested in accordance with ASTM method D-1792-66.
10. The product should not be acid sensitive, and should resist acidic cleaners and strippers, including acidic soft drinks and fruit juices.
11. The finish should be non-yellowing on the floor and should be milk white in the original container, rather than tan.
12. The finish should have a coefficient of static friction on the floor greater than 0.50 when measured by the ASTM method D-2047-69, and, accordingly, is considered safe.
13. The finish should be film-forming at usual temperatures and should produce no powdering or crazing.
14. The finish should be completely waterproof within 12 hours after application.
15. The finish should be free from objectionable odor and must not develop an offensive odor upon storage in the original, unopened container.

Specification for
Water Emulsion Type Floor Wax or Finish Remover

Scope	This specification covers commercial wax remover for use in stripping water emulsion floor wax or finish (including the metal-link polymers) from vinyl, rubber, asphalt, and other composition floor surfaces. Also for use as a heavy duty cleaner for ceramic and conductive floors.
Type	The compound should be a liquid of one grade only.

Requirements

1. The compound should be a homogeneous, highly concentrated free flowing liquid to be diluted with clear water. It should be composed of synthetic detergents, alkaline builders, and sequestering agents. It should not cause skin irritations when used in accordance with directions.
2. The compound, in use-concentrations, should be *free rinsing* and free from any objectionable odor.
3. The compound should not contain any fatty acid soaps.
4. The compound should be stable and not lose its original effectiveness or otherwise deteriorate when stored for nine months in a closed shipping container at room temperature.
5. The non-volatile content should not be less than 6.5 percent at 105°C.
6. The pH value of a 1.0 percent by weight solution should not be more than 12.0 when tested with a standard pH meter.
7. The compound should be completely miscible with tap water in all proportions. It should be stable and clear between a temperature range of 32°F and 100°F.

8. The floor wax removal compound should remove 95 percent of a wax film as determined by instrumental measurement—the reflectance of a light-colored, unwaxed standard linoleum panel is compared with that of a panel that has been waxed with a standard, dyed-water emulsion wax and then stripped. Measurement is made on a Hunter Multi-Purpose Reflectometer as described in paragraph 4.4.6 of Federal Specification PR-20 lb.
9. The product should remove grease, oils, waxes, gums, dirt, and hard-to-remove soils from all recommended surfaces when used as directed.

CHAPTER 8

Use of Computers in Maintenance Management

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8.1 WHY COMPUTERIZATION?

Only a person returning from a *long* cruise or coming out of a coma could be unaware of the revolution in data processing and automation. Today maintenance managers fall into two groups—computer users and those about to become computer users.

Still legitimate questions remain—Why? Does it make sense to go through the time and expense of converting present operations to computer systems? Managers can use the following simple test to measure their readiness for using computers for maintenance management (check one or more boxes):

- ☐ I need to save money this year on my budget.
- ☐ I can get a good deal on the hardware.
- ☐ I'm taking a course—Introduction to Data Processing.
- ☐ Most of my professional associates use a computer in their operations.
- ☐ None of the above.

If you checked any reason other than the last one, you will be in for disappointment and grief. This chapter will explain exactly why.

In the long run many computer applications for maintenance management will pay back handsomely. But for the first year, or more, costs are likely to exceed benefits by a wide margin. Computer system start-up costs, for even modest applications, can run beyond expectation. It is not unusual to exceed budgets for hardware by 20 to 30 percent and software by as much as 100 percent. These cost overruns have five basic reasons:

- Forgetting to budget for peripherals—extra terminals or printers, stands, cabling, and adequate disk storage for data bases that are larger than anticipated.
- Failing to consider other applications that suddenly become compelling once the system is operating.

- Everything taking more time than was estimated.
- Paying for service calls to fix things that weren't broken.
  Discovering that problems were operator errors caused by a lack of training and understanding.
- Finding that the limited software package selected inadequately met actual management needs.

Managers should consider computer applications for maintenance management because manual and semi-automated solutions cannot handle the complexities of effective facilities management. With the many uncertainties surrounding both revenue (will enrollments flatten or decline?) and costs (what will happen to energy costs this year?), maintenance managers of education facilities need the best decision-making tools available in order to use resources most effectively.

It is certainly possible to establish and operate a manual preventive maintenance system. Several companies produce systems that use specially designed cards in racks or trays with color-coded tabs to indicate schedule due dates. Entering information on to the cards takes no longer than entering the same data into a computer terminal. If there is an error on the card, however, it has to be thrown away or, at best, erased and retyped. On a computer terminal, a few keystrokes correct the error while saving the remaining accurate data. Similarly, retrieving information from a single card may take only a minute or two—not much longer than calling up a single inventory item on the computer. But sorting and compiling records for reports is another story altogether. The computer does chores in seconds that require hours—or even days—for a clerk to complete.

There is a particular difficulty in comparing costs of operating a computer system with a manual or semi-automatic system. With a computer system managers would never be satisfied with the crude, aggregated information available to them from manual systems. Labor cost reports provide an example of this principle. Without a computer system (or even with one that is not programmed to generate the proper reports), labor costs are probably analyzed only as far as the following:

Total Payroll Costs, week ending 2/13/84	$27,506.30
Physical plant administration	1,753.40
Carpenter shop	2,369.75
Plumbing shop	1,650.00
Metal shop	1,308.00
Electric shop	3,215.60
Central plant	4,692.10
Custodial	4,800.60
Grounds	1,408.60
Laborers	1,208.25

With an especially hard-working staff, further distribution might include—

Trades and Mechanical

Preventive maintenance and central plant operation	$ 6,516.70
Alteration and modification projects	4,561.69
Repairs and emergencies	1,955.00
Annual and sick leave	906.06
	$13,939.45

But with a properly designed computer system, a manager could expect all of the above data plus the following:

- Detailed work order costing, current week and year-to-date.
- Work order budget versus actual labor, current week and year-to-date.
- Absentees by shop, name, or badge number; hours in current week and year-to-date.
- Percent of all allowable labor cost by building, current week and year-to-date.
- Lost-time report by craft and type of delay, current week and year-to-date, percentage of total time.

There is only one reason to convert maintenance management systems to the computer. Computerization enables one to manage better—so much better it is hard to imagine how we operated before. A well-designed computer system allows maintenance managers to make decisions that put them in control of situations that they only reacted to previously.

8.2 ORGANIZING AND SELECTING THE SYSTEM

Start with Applications

Managers sometimes mistakenly establish a staff, negotiate for hardware and software, and then design applications. This is exactly backwards. The kind of system, including the number and caliber of people to operate it, is a function of what you want to accomplish. There are dozens of possible applications for computer systems in maintenance management. Some are stand-alone or single-purpose applications. Others are integrated into an interactive system where transactions flow from program to program, file to file, interrogating and updating records on a continuous basis. The following list illustrates a few of the applications.

Single-Purpose Application	**Interactive with**
Key Control	Intrusion detection/security
Alarm Circuit Testing	Security monitoring or building management system
Space Management	Space and facilities data base
Space Inventory	Space and facilities data base
Personnel Management	Payroll and labor cost
Work Order Monitoring	Work control system
Work Order Costing	Work control system
Preventive Maintenance Scheduling	Planned maintenance and work control system
Deferred Maintenance Backlog	Programmed maintenance system
Cyclic Maintenance Work Order/Projects	Programmed maintenance system
Budget/Financial Management	Work control system
Stores Inventory System	Work control system
Bench Stock Inventory System	Work control system
Energy Management Systems	
Supervisory Controls	Building management system
Load Shedding Start-Stop	Building management system
Flow Rate Optimization	Building management system
Building Management Systems	
Fire Alarms and Recording	Energy management system
Security Detection Alarm	Energy management system
Equipment Operation Control	Energy management system

Because the last two major categories, Energy Management and Building Management Systems, are functions of data points and circuitry rather than management information, they have been dominated by large manufacturers of alarms and thermostats. Until recently, the packaging and costs for these systems obscured the primitive logic and decision-making capability of the systems. There are now several cost-effective systems on the market with varying reputations for reliability, product support, operator training, and service. An engineering study by a firm specializing in design and selection of building management and/or energy systems could be the best possible investment before inviting vendors to submit proposals.

Remember two simple rules when considering computer applications for maintenance management.

- Start with the area most likely to payback rapidly.
- Don't try to begin with a grand scale, interactive system. Do plan to join logical modules or sub-systems later on. In order to do this planning effectively, you will likely need the help and advice of a qualified systems analyst.

Managers approach choosing the application with the best payback the same way they make any other management change. Treat it as a problem in work simplification or value analysis. Ask these questions:

What made me mad today?
What took too long?
What was the cause of a complaint?
What was misunderstood?
What did we waste?
What job took too many people?
What cost too much?
What was too complicated?
What job involved too many motions?

The answers should provide a long list of needs. Then have staff, key supervisors, and managers answer the same questions. Their contribution is needed before making a choice. Also quiz a few workers for ideas and suggestions. Ask them to visualize a genie offering them three wishes to change anything about their work environment that would benefit the organization as well. They often come forward with valuable observations and insight.

Commercially Available Software

After choosing an application for investigation (and you may start with a dozen), search for already-developed software. Some programmers disparagingly refer to it as "canned" software. The term should not bother you. It's much better to eat canned food than to go hungry or pay too much for fast food. Look for commercially available software because custom developed systems cost 10 to 50 times as much. Be realistic. The first year whatever you spend on hardware, you are likely to spend an equal amount for software. If you insist on custom development, the cost can be much greater. In examining existing software, there will probably be desirable features that are not available. But that reflects the trade-offs made whenever we shop for a house, an automobile, or select a vendor for cleaning materials.

There are several ways to analyze canned software. One is to have the vendor demonstrate it. This is usually slick and impressive—as long as you stay with the demonstration setup. You may be able to envision how the application could be changed to fit the department's requirements and circumstances and the difficulties that might be encountered. But this is not realistic or reliable. In simulating your situation you may be able to "crash" the system. If so, you have made an important discovery. Look further.

Documentation The ideal software package would be designed by geniuses to be run by idiots. After looking at the documentation—written instructions for using the program—you might think it is the other way around. Examining documentation is an inexpensive way to estimate the level of difficulty a software package might present. "Brochures will not do; you need the manual that describes the program's capabilities and operating procedures in detail. Reading the manual is important on two counts: it gives you a good idea of the program's true capabilites, and it tells you what level of documentation your operators will have to cope with, should they be called on to use these programs."[1]

Writing for a special "Computers" section of the May 1982 *AirCal Magazine*, Umberto Tosi and Dina Moro Sanchez offered the following advice:

> A once-over of a computer product's documentation will shed light on three main considerations crucial to deciding if that product is right for you.
>
> - It can tell you specifically just what the equipment or program can and cannot do.
> - It can give you an idea of how easy or difficult it is to perform the machine's or program's operation.
> - The quality of the documentation itself, especially its accessibility, will tell you if you will be able to rely on it to solve problems as they arise, refer to it on a variety of operations, and/or use it to train employees and co-workers.
>
> Good documentation has the following characteristics:
>
> - A concise, two- or three-page overview of what the equipment can do.
> - A set of instructions, written in plain English, that show the user how to set up and operate the machine or program in a step-by-step manner. The instructions begin with the simple and move to the complex.
> - A reference section for routines and functions rather than a list of technical specifications. Finally, good documentation should include separate 'cheat sheets' or laminated cards for quick reference to the most commonly used commands and functions.[2]

8.3 PRELIMINARIES TO SYSTEM SELECTION

Only after developing a list of available software packages that appear to meet the requirements of the highest priority applications, should you consider operating systems and hardware. Ideally, defining the application would lead to selection of available software. Optimum software selection would dictate the range of possible operating systems, which would in turn indicate hardware availability.

In practical terms, however, there are other considerations. Some institutions have central data processing departments and dedicated systems with certain availability criteria. Further, institutional policy may give the data processing department veto power over all new computer applications. Fundamental differences exist between operating as a remote terminal or batch-process user from a central mainframe versus using a stand-alone or dedicated small computer.

Note the working definitions that follow. Understanding the jargon, lingo, or terminology is vital to the chapter's remaining discussion.

A Short Glossary

Batch Processing—This method of processing accumulates data entry in groups or batches (such as decks of punch cards) and processing is done at a later, scheduled time.

Central Processing Unit (CPU)—A CPU contains the electronic logic that actually receives individual instructions and causes the events specified by the instructions to occur.[3] The CPU is connected to the memory and an external interface.

Computer or Computer System—The computer is "a box containing a lot of electronics; on its own it is useless. The computer without a computer system is equivalent to an engine without an automobile. And the power of the computer determines the amount of computing a system can do."[4] A computer system contains a central processing unit (CPU); an information storage unit (tape or disks); and Input/Output (I/O) devices such as a keyboard, a CRT display screen or monitor, and a printer.

CPU Memory—Memory is information stored in an electronically coded fashion. Two types of memory are found in computers: read/write memory or Random Access Memory (RAM), which is lost when power is turned off; and read only memory (ROM), which is not lost when power is off. In some personal computers, ROM contains a few important programs that bring the computer to life when the power is switched on. The most important one is called the bootstrap program, because the computer "pulls itself up by its own bootstraps." Computer experts say the program "boots" the operating system.

CRT Monitor—The cathode ray tube video screen displays information, conditions, commands, instructions, and graphics for the operator or user.

CRT Terminal—A CRT monitor and keyboard are combined in one unit.

Data base—A data base is a repository of stored information organized in such a way that data are easily retrieved. The term is generally associated with an organized base of data that is stored within a computer and usable by multiple applications. An everyday example of a non-computer data base is the telephone directory.[5]

Field—In a data base management system (DBMS), a field contains an item of information. It corresponds to the column of a paper data base. A field description consists of three parts: the field name or title; the field type (whether character, numeric, or logical), which tells the kind of data that may be stored in a field; and the field width (number of spaces needed in the field to contain the data).

File—A file is a collection of information or records such as a data base or a command file organized and stored for a specific purpose.

Keyboard—A keyboard is "similar to a typewriter keyboard. It is used to 'talk' to a computer."[6] For data entry, a numeric (10-key) pad is a desirable feature in addition to the typewriter keyboard. Other special keys peculiar to computer applications such as control, function keys, and cursor control/directional keys are generally part of the keyboard.

Mainframe—A mainframe is a large data processing system operated at a central location for many users who submit jobs for batch-processing or enter data and control programs on-line from remote terminals. "In general, mainframe computers are the largest and most powerful machines, minicomputers are intermediate, and microcomputers are the smallest. In reality there is a lot of overlap among products."[7]

Mass Storage Memory—"Peripheral storage devices such as disk drives and tape drives"[8] provide a place to store programs or data created in the random access memory. This way information is not lost when the power is off and more than the internal memory capability may be used. Without mass storage memory, a computer is little more than a toy, since this is where files and records that are routinely accessed and updated reside.

Microprocessor—The microprocessor is the CPU of a microcomputer or computer-on-a-chip. It uses Large Scale Integrated (LSI) circuits or Very Large Scale Integrated (VLSI) circuits. A single 64K chip may be no larger than your thumbnail, although the most common ones are about 2 inches (51 millimeters) long.

Minicomputer—This term is rapidly losing its significance. Minicomputers were once scaled-down mainframes designed for smaller applications, not as powerful or fast as mainframes but useful for multi-terminal, multi-task use. The average minicomputer system costs $25,000 to $100,000, contrasted with microcomputer systems that cost $2,000 to $20,000. "There are some minicomputer manufacturers whose products cost two or three times as much as a microcomputer without being any better. They still manage to sell, based on slick advertising and a history of satisfied customers. But the successful and growing minicomputer manufacturers charge more because they offer more."[9]

Multi-user and Multi-tasking—"Multi-tasking computer systems perform a number of chores concurrently. Other names that refer to this capability include multi-user, time-sharing, time-slicing, multi-programming and multi-terminal." Multi-tasking, in its simplest form, requires the CPU to perform a second job while it waits to continue processing a first job. This is the time in which the operator, keyboard, and input/output device are creating and capturing another character for the CPU to process. "The computer appears to perform two things simultaneously since the tasks outlined above are measured in thousandths or millionths of a second."[10]

Networking—Hardware and software are designed to connect individual computers to a common data base, such as TELENET, the SOURCE, and others.

On-line Processing—To process information on-line, a system senses and responds to changes as they occur, generally from a keyboard or terminal. The term applies to systems in which information is introduced and processed immediately.[11]

Operating System—An operating system is an "integrated collection of service routines for supervising the sequencing of programs by a computer. Operating systems may perform debugging, input/output, accounting, compilation, and storage assignment tasks."[12] Many operating systems are "dedicated," which means they work only on one manufacturer's computer, while others are designed to fit any computer using the same or similar CPU. There are almost always differences from one manufacturer to another that require modifications to applications programs.

Peripherals—Peripherals are "devices used with the computer such as a printer and disk drives."[13] Computers lacking these devices can do little more than calculate or play simple games.

Program Language—The program language is a set of conventions by which programmers tell the computer how to make programs work. Examples of commonly used languages include COBOL, FORTRAN, BASIC, and 'C'.

Record—A group of one or more words containing related information about a common subject creates a record. One or more records create a file.[14]

Report—A report consists of logically arranged and formatted information useful to managers. A report may be as simple as a list or as complex as a general ledger.

Software—Computer programs, or the instructions to the machines, are called software as contrasted with the components of a computer system, referred to as hardware. Software is broadly divided into two classes: system software and applications programs. "System software generally includes programs that make the components of the computer system act as a system. Applications programs make the computer, acting as a system, perform a particular function for you."[15]

Institutional Policies and Considerations

In the decision-making process, managers should examine the trade-offs between using a central data processing department's mainframe versus operating a stand-alone system. Institutional policy may already dictate the method used.

Data Processing Department Mainframe

Pros	Cons
1. Should have powerful, fast equipment.	1. Equipment may be fast, but not readily available to administrative departments. You may be relegated to batch operation only, or—if using a terminal on-line—you may find instructional and other uses occupy the equipment all day. Fast internal processing means nothing if you do not have access to it for your work.
2. Staff is available to manage the facility, set priorities, deal with hardware and software maintenance people, handle system upgrades, etc.	2. DP staff may see physical plant jobs as a nuisance and give your work low priority.
3. DP programming staff should be available to custom fit software to to your needs, support your usage by debugging, and make changes as needed.	3. DP staff may chose *not* to support your software usage.
4. DP manager has to make all the tough decisions about allocating scarce resources of time, storage capacity, and programming support.	4. DP manager is responsible to whole institution, not just facilities. Priorities may not suit your needs.

Facilities Department Stand-Alone System

Pros	Cons
1. No question exists about resource allocation—*all* goes to physical plant.	1. Several potential applications in maintenance may compete for time, disk storage space, software purchase, or development budget. Now the manager must become his or her own DP manager and make tough decisions about resource allocation.
2. The department will be able to use bright student assistants to do lots of programming—cheap.	2. Bright student assistants graduate or leave for greener pastures. Unless they document extremely well as they program, the

	the department may be stuck with software that cannot be used or modified, or is unreliable due to lack of testing.
3. Facilities managers can add to, upgrade, or change hardware and software anytime budget justification exists.	3. This may or may not be true, depending upon the institution's procurement and control regulations. New hardware or software procurement may require feasibility studies and various levels of approvals.

Stand-alone systems are usually *not* going to be supported by the institution's central data processing department. They simply can't afford it. This means that the plant department must have a DP person of its own or use only well-written and well-documented, user-friendly software. Someone must be responsible for managing the in-house computer and its resources: CPU time, disk storage space, software and peripherals budget, maintenance agreements, and warranties. Managers need sound advice on prospective applications in order to evaluate the costs and benefits and then set priorities. There are drawbacks to investing heavily in one specialist. This person may soon learn enough to be able to sell his or her capabilities to the highest bidder. An alternative may be to have on retainer a systems analyst. He or she would be available on fairly short notice, and would be knowledgeable of the department's hardware and system capabilities, software (both system and applications), and maintenance needs.

Generative/Intermediate Software

Before choosing a particular computer system, investigate what the vendor can offer in generative, or life-giving, software. Adam Osborne calls it intermediate software. Generative software may be more important than the special applications like preventive maintenance or inventory control that are your highest priorities. There are three major innovations, developed in recent years, that fit into this group: word processing software, data base management systems, and electronic spreadsheets.

These programs are invaluable. Once mastered, they open the door for many, many applications that individuals—non-DP managers—can tailor to suit exact needs. There are many variations of each of these innovations.

Word Processing First, consider the merits of word processing. If budget restrictions allow for only one software package, this is it. We have experienced the change a good word processing software package makes in an office. In an engineering firm where two secretaries could not keep up with correspondence, proposals, and reports, one operator who had mastered word processing was able to more than equal the previous work output. There are many word processing packages on the market. For personal or single-user small computers, one of the most popular is designed to run on the CP/M™ operating system. Word Star™ also has the dubious distinction of coming with documentation that is extremely vague and hard to understand. Happily, this has been ameliorated by the publication of a well-written text, *Introduction to Word Star*™, by Arthur Naiman. Naiman's connection with Word Star™ is strictly as a user who grew frustrated with the manuals and wrote his own. In his book, Naiman explains what word processing can do for the user:

> Basically, a word processor does what a typewriter does, only better. The main difference between them is that on a word processor, what you write is stored as electronic (or magnetic) impulses, instead of as marks on paper. Word processors can do this because they're computers that have been programmed to let you type in text, edit it, and have it printed out.
>
> You type on a word processor just like on a typewriter, but instead of the text appearing on a piece of paper, you see it on a screen—a CRT or cathode ray tube similar to the one on your television set. The text only shows up on paper when you order a printout (also called a hard copy). It doesn't matter when, or how often, you make a printout of the text. This gives you the freedom to make whatever changes are necessary, without having to worry about all the retyping that such changes would normally involve.
>
> A word processor also lets you:
>
> - Change a word (or an entire phrase) everywhere it occurs in a manuscript, in a matter of seconds;
> - Move whole sections of text around from one place to another (and then move them back again if you want);
> - Find the next (or last) occurrence of any word or phrase; and
> - Store blocks of text and print them out in various combinations.
>
> When you go to print out your text, you have available several effects you can't get (or can't get easily) with a typewriter. Some examples are boldface, automatically centered lines, justified right margins, automatic page numbering, automatically indented blocks of text, and automatic paging.[14]

Applications of word processing to maintenance management include specifications for projects especially where standard language, or boiler plates, must be merged with special conditions; personnel lists and rosters; and correspondence of all kinds. Word processing is particularly useful in drafting agreements where many changes must be made before the final text is approved—as in labor negotiations.

If word processing will be used in a multi-terminal environment, select a word processor that works on the operating systems available. CP/M™ is not a multi-terminal operating system; therefore, Word Star™ could not be used with a multi-terminal version of the operating system.

Data Base Management System The second type of generative software to research is a data base management system (DBMS). Just as there are many word processing systems, there are many data base managers. Availability for different operating systems, languages, and hardware vary, but several run on the ubiquitous CP/M™. Non-computerized data base management systems include the telephone directory, an auto parts store, and the college or university library. The telephone directory provides a great deal of information (address, phone number) accessed by only one key—NAME. A more sophisticated directory is the city criss-cross directory in which residents can be found by address as well as by name. The telephone company can also search their database by telephone number and find the name of the subscriber.

In an auto parts store, a customer tells the clerk that he needs a master cylinder for a 1973 Volkswagen Beetle. The clerk looks up the part in the set of catalogs that provide an identifying part number, a bin location for the part in stock, and a price. The clerk, catalogs, price lists, and storage bins correspond to a data base management system. The actual parts on hand correspond to each item of information in the data base.

In large libraries one is not allowed access to the stacks where the books are kept. Instead users must search through the card catalog and various indexes for the information they want. The user then writes the code numbers of materials on a slip of paper and gives it to the librarian who in turn sends a "gnome" to the stacks. The gnome retrieves the book or periodical. In this case the book is the data item and the card catalogs, indexes, librarian, gnome, and stacks correspond to the data base management system.

The above illustrations fall short of describing the power of a well-designed DBMS. Far from retrieving single items of information, the DBMS can be sorted and manipulated to produce reports of all types. In an inventory system, for example, the reports might include the following:

- A catalog of all line items including quantity available, average unit price, and descriptive information.
- A list of inventory that has not moved (0 issues) in the past six months.
- A list in descending order of fastest-moving inventory items.
- Calculation of total inventory value and the number of "turns" for past year.
- A buy-list for items reaching minimum quantity level, with economic order quantity of each.

Small businesses use data base management systems for such operational areas as payroll and accounting, standard tax reporting, inventory management, flooring charges, mailing lists, daily cash register tally, and transaction recording. Maintenance and plant engineering organizations use DBMS software for tracking all kinds of information including emission logs, health and safety records, vendor performance records, and hazardous waste manifests.[17]

Electronic Spreadsheet The third category of generative or intermediate software worth investigating is the electronic spreadsheet. The most popular versions are VisiCalc™ by Visicorp, Inc.; Multiplan by Microsoft Corporation; and SuperCalc™ by Sorcim Corporation. An electronic spreadsheet is nothing more than an array or matrix of rows and columns for repetitive calculations. Its name implies its primary use: as an electronic version of the accountant's columnar pad. The beauty of its use is in asking "What if" questions for simulation purposes. For example, a pro-forma statement projecting profit/loss for a period of time can be created for a given set of conditions. Any number of variables or relationships may be changed and the program recalculates the results instantly. The entire spreadsheet may be stored in memory, printed out on hard copy, or only variables without values may be saved for future use. The applications for an electronic spreadsheet are limited only by the user's imagination.

Applications in maintenance include calculation of staffing requirements for custodial, grounds, or equipment maintenance. Once operational tasks are identified and time standards established, quantities and frequencies may be manipulated to determine effects on manpower requirements. Budget planning may be the most used application in maintenance. A spreadsheet can be used to see the consequences of budget reductions or unfunded replacement reserves.

System Requirements/Specifications

Whether the hardware purchased is a packaged system or components and whether the software is canned or custom designed, someone must prepare a set of specifications in order to know what is needed and how to buy it. When computer hardware cost $25,000 to $200,000 and more, almost all software was custom designed. Paying a consultant $10,000 to $30,000 for a specification was easily justified. When a whole system—hardware and software—costs $10,000 to $20,000, such a specification is not justifiable. Yet there must be one, just not in as much detail. The answer is to write your own specification.

A specification is a description of the functions the system should perform. In writing a function definition, list everything you want the computer to do. Later you may decide to have some tasks performed manually as they are now. A function definition should include these four parts:

- An operations summary.
- A description of information the computer is to store (files).
- A description of information that will be put into the computer (records).
- A description of information that managers want the computer to generate (reports).

The Operations Summary Define all the functions you expect the computer to handle. The definition should be complete in scope, but not in detail. The detail, if needed, can follow later. Complex functions should be represented by using block diagrams that show the interaction (if any) between different operations.

The next step is to determine which files are accessed by more than one function. For each function make a list of all the files accessed by that function and their sizes in numbers of characters.

In the following examples note that the estimates used are for small business applications and expand many times in larger organizations.

Operation 1: Accounts Payable

Vendor Accounts Records	25,000	characters
Cash Journal	5,000	"
Total for Operation 1	30,000	characters

Operation 2: Accounts Receivable

Customer Records	10,000	characters
Cash Journal	5,000	"
Total for Operation 2	15,000	characters

Operation 3: Payroll

Employee Records	12,500	characters
Payroll Records	50,000	"
Total for Operation 3	62,500	characters

Operation 4: General Ledger

Cash Journal	5,000	characters
Payroll Records	50,000	"
Total for Operation 4	55,000	characters

Some approximations: Payroll typically uses 250 characters/employee; Accounts Payable and Accounts Receivable use 100 characters/transaction; General Ledger uses 100 characters/entry; Inventory uses approximately 100 characters/line item of inventory.

Each character requires one byte of storage (1 byte = 8 bits), and mass memory storage is measured in Kilobytes (1 K = 1,024 bytes) or Megabytes (1 M = 1,048,576 bytes). Thus, we begin to see the storage requirements realistically.

Data Input For complex functions describe the information that must be input to each function. Write a short description of each input operation. Estimate total characters input for each operation and divide by average typing speed to estimate the minimum time required to input information for each entry time. Some items may require input monthly (accounts receivable), some weekly (such as payroll), and some semi-monthly (such as accounts payable) if bills are paid twice each month. From these estimates, you can construct a calendar of input time required.

Data Output Write a brief, narrative description of each report you want the computer to generate. Estimate the number of printed pages each report represents and how often you want the report generated. List all reports to be printed, the number of pages per report, and the frequency to be printed. Summarize the output demands to be made of the computer. This will be helpful in selecting the system.

Similarly, thought should be given to how often data will need to be displayed on the CRT screen but not printed. This will help determine whether one terminal will be enough.[18]

General Steps for Computerization

The steps to follow in selecting a computer system today do not differ from those described in 1970 by Edmund J. Wells, management advisory services manager for Haskins & Seils. Wells outlined these steps in the process of mechanizing the small office:

1. Determination of objectives and advantages.
2. Definition of requirements.
3. System design, evaluation of alternatives.
4. Design implementation.
5. Conversion.
6. Continuing operations.

According to Wells participants in this process should include top management (represented by a results-oriented project head), middle management (represented by a project coordinator), office staff, a consultant, and the manufacturer's representative.

The consultant, or systems analyst, would produce much of the work needed for steps two and three. This includes help writing the entire function definition described above. Few managers are able to develop this information without professional guidance. In describing step three Wells wrote,

> A preliminary evaluation will normally allow the system approach to be determined and the vendor list to be narrowed to four or less—preferably less. The proposal request should encourage creative system design by the vendors. Where adequate, proven package systems should be selected in preference to custom systems.[19]

8.4 SPECIFIC MAINTENANCE MANAGEMENT APPLICATIONS

The specific use of computers for work order control, preventive maintenance, and inventory control is also discussed in Chapters 2, 3, and 5 respectively of Part III.

Labor Reports

One of the real tragedies of the past 20 years has been the selection of payroll as one of the first uses of the computer. Because of the highly repetitive transactions and fairly simple logic, it seemed a natural. Unfortunately many of these early systems were designed to produce little more than payroll and the mandatory reports required by the Internal Revenue Service. Thought was not given to the other uses of the same data, such as personnel information and labor cost (a component of job or work order costing). Consequently, we remain plagued by payroll systems that furnish no real management reports.

Payroll, personnel, and labor cost reporting systems share many of the same data elements. This has led to the popularity of using data base management systems for these functions:

Payroll System	Personnel System	Labor Cost System
Employee Name	Employee Name	
Employee Number	Employee Number	Employee Number
Employee Rate Gross Pay	Employee Rate Gross Pay	Employee Rate Gross Pay
Employee Dependents	Employee Dependents	
Withholding Data		
Employee Net Pay		
Employee Hours Worked	Employee Hours Worked	Employee Hours Worked
Leave Hours Earned	Leave Hours Earned	
Leave Hours Taken	Leave Hours Taken	Leave Hours Taken
		Hours Worked Job

While the above data elements list is not complete, it illustrates the point that, with planning, a system can provide one data base that satisfies the needs of several different systems serving different management functions.

Definition and Design In order to calculate and establish the proper data base requirements, we must begin with the desired reports. From report format and content, we can establish the data element listing, which—when defined—becomes the data element dictionary.

Before designing report layouts, think about the uses of the reports for managers. What we might want to know includes—

- Personnel complement. How many people by classification do we have on the payroll?
- Active or inactive status. For a specified period were any employees on disability, medical workers compensation leave, military leave, or any other leave of absence of a long-term nature?
- Short-term paid leave or unpaid absence. How many people of which classification and pay rate were on annual leave, sick leave, personal holiday, or other short-term nonworking time, paid or unpaid?
- Net work time to be accounted for. By classification, how many hours were charged to actual work time?
- Does absenteeism plus actual work time account for all hours represented by total personnel complement in the pay period? If not, what is required to reconcile the difference?
- Where were actual work hours used? Progress and cost monitoring required detail showing distribution of hours and cost compared to work orders (by number), zone or building, craft or shop, type of work (preventive maintenance, repair, operation, project), and if any hours charged to accounts for which reimbursement is forthcoming.

The first three items might be combined in a single listing or generated in separate summary reports. The format should be determined by the use for the information. Similarly, the last three items could be presented as individual, detailed listings or arranged as portions of a management summary. The best way to develop layouts is to take previously developed information and arrange it in various ways. Then use the configuration that presents the information managers need in the most readable form. Do not accept a report format that is unwieldy, hard to understand, and does not summarize data in a concise manner. If a manager has to read through pages of printouts with a calculator in hand to summarize the real data, valuable management time is lost.

Once the format and data elements are agreed upon, the data elements list and data element dictionary should be constructed. The length and quantity of records are a matter of arithmetic, but true file size and storage requirements are a function of the operating system. As a rule of thumb, a fairly complete labor reporting system requires about 400 characters per employee on the system (whether still on the payroll or not, employers must maintain former employees' records until the end of the tax year).

Preventive Maintenance

There are great variations in complexity among preventive maintenance systems. The simplest systems store an inventory list of items to be maintained and work orders. The work orders are arranged in some schedule (in code or full text) that tells workers which task is to be performed. The minimum data input to a preventive maintenance program is—

- The types of equipment (or other items such as roofs or drains) to be maintained.
- The number of items there are.
- The location of each item.
- The task to be performed and its frequency.

It is also preferable to determine—

- Which craft or shop will perform each task.
- Length of time the task should require.

With this information, it is possible to build a schedule of total manpower requirements by craft. With this schedule, managers can balance the workload over the year and maintain relative frequency intervals between performance of each type of task (monthly, quarterly, semiannual, or annual).

After work is performed, it is desirable to capture certain information from completed work orders:

- List of work orders completed each period. Those work orders still open or uncompleted.
- The time charged to each work order. Compare actual time to the standard established for the task.
- Repairs needed beyond the scope of the preventive maintenance mechanic.
- Report of work orders written for such repairs.
- Any outages required to schedule the work on a given system. List of people to contact before outage.
- Equipment maintained only during the heating season, or only during the cooling season.

With all the above information built into the original data base, the system can be designed to capture historical information, print outage requirements in advance, give management current and year-to-date cost data, develop trend information on percentage completion or preventive maintenance tasks by craft, and compare standard times versus actual times for types of equipment and crafts.

Data storage requirements will range from about 300 characters for each inventory item in a single system to as many as 2,500 characters for each item in a comprehensive system. On a large campus even a simple system would be hard to accommodate with a floppy disk computer system.

Inventory Control

As in preventive maintenance, the capabilities and complexities of inventory systems vary. At the most basic, an inventory system classifies stock and allows for perpetual updating of quantity on hand by a simple formula:

Beginning Inventory
+ Acquisitions
− Issues
+ Turn-ins (items returned unused to stock)
= Ending Inventory

If a dollar value, as well as description and quantity, is assigned to each class of item, then inventory valuation may be kept current as well. LIFO (Last In/First Out), FIFO (First In/First Out), and Moving Average are popular costing methods.

It is important to know what is on hand, and how it is moving (inventory "turns"). How close to a predetermined optimum level present quantities are also becomes significant. A more comprehensive system can calculate economic order quantities, list vendor sources for stock needing replenishment, write purchase orders (even issue sight drafts), and cost out issued quantities to work orders.

Simple inventory systems that require manual updating of reorder quantities may require as little data storage as 100 to 200 characters per inventory line item. A comprehensive, interactive system may need 1,000 characters per line item.

Work Order Control

Computerized lists of active work orders are great time savers even in their simplest form. Because work orders are written to be performed (completed), the very nature of the record keeping is dynamic. This is especially true when multiple crafts are involved and material must be processed before scheduling work. Large work orders may remain active or open for many weeks or months. Updating the status alone requires a great deal of retyping of lists. Therefore, a simple system should contain at least the following data:

- A log of when a work request was received, the order number assigned, date approved, and date sent to shop(s) for completion.
- Estimated value in labor and materials, by craft.
- List of work orders completed during a given period.
- List of work orders not completed or open.
- Completed labor cost data, by craft and materials.

A more comprehensive system interacts with payroll and inventory systems to produce these reports:

- Available manpower by shop for future weeks.
- Sequencing of operations among crafts on larger jobs.
- Backlog of work orders not in process, reported by craft, labor hours, and materials dollars.
- Priorities currently assigned each work order.
- Outage data for each work order.
- Procurement status on materials not in stock of each work order.
- Cost data in variety of ways for management purposes.

Simple work order control systems require data storage in the range of 250 characters for each work order each year. More comprehensive systems require up to 2,000 characters for each work order each year.

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PART IV

OPERATIONS MANAGEMENT

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INTRODUCTION

Changing Operations Needs

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The operations management section discusses some of the most important, though oft-times unheralded, responsibilities of facilities administration. These are the methods to carry out the energy conversion and conservation, utility distribution, building locking, and transportation activities at a college or university campus that are vital to the complete and satisfactory functioning of the institution's facilities.

The advances in plant operations during the 1970s, with their incumbent responsibilities, have been unlike those of any other time. For during that decade sweeping changes were brought about by events, both positive and negative.

One such event was the energy crisis, which caused all institutions to reassess their operations. As a result, most institutions changed abruptly from a "study state" condition—in which building systems were operated uncontrolled 24 hours a day—to a state in which services were provided only during periods when buildings were occupied. Larger campuses replaced manual clocks with sophisticated central control and monitoring systems.

Another major force that produced a profound influence on plant operations was the advent of mini and microcomputers. The rapid advance in computer capabilities, coupled with their increasing affordability, brought facilities managers the opportunity to have critical management information instantly available. Such quick and easy access to information is essential not only during periods of budgetary stress but is vital, too, in monitoring planned maintenance programs and in reviewing maintenance history. The computer enables facilities managers to make informed decisions to repair or replace equipment or facilities.

The discussion of operations—separate from maintenance—in this book is an attempt to show *methods* for carrying out the day-to-day services expected of the facilities department. Though not a national trend at institutions, the operations center structure—in which all facilities activities are centrally scheduled, monitored, and controlled by management—is beginning to be used. This technique has become possible with the advances of computerization.

Chapter 1 presents an overview of plant operations. Succeeding chapters explore specific operations functions such as central utility plants, utility distribution systems, building mechanical and electrical systems, key issue and control, computerization of plant activities, central control and monitoring systems, energy management and conservation, and related topics. In these chapters we have tried to provide sufficient information for facilities managers to review current operations and consider changes that will improve their ability to direct and control the operation in the most efficient and effective way possible.

The information presented in these chapters is not a "how-to" guide to utopian plant operation. Rather, it is an explanation of concepts accompanied by sufficient information to allow administrators to make a decision on whether to introduce those concepts to their organization. If administrators choose to phase in changes, the authors offer guidelines to enable those changes to be implemented with a minimum of problems.

Technology is moving at a rapid pace in our information age. Therefore we urge facilities managers to consult not only the material presented in this book but also to consider current specific technological advances before making final decisions. The information in this book should provide ample background to make that course of action possible.

CHAPTER 1

Overview of Plant Operations

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1.1 SCOPE

The plant department performs a multitude of diverse support and service functions that contribute to the successful accomplishment of the missions of virtually every department and office of a college or university. None are more essential than those relating to the day-to-day operation of the facilities—the central plants, utility distribution systems, building mechanical and electrical systems, telecommunications, building locking systems, and other such support systems and equipment. Malfunctions in these operations not only interrupt teaching and research, but can result in serious losses such as expensive repairs, energy waste, and destruction of ongoing research projects.

The continuity of operations cannot be left to chance. Steady-state performance must be achieved through an understanding of the equipment's capabilities and limitations as well as an organized system of monitoring and adjustment. This part of the manual consequently concerns the functioning of the facilities. It includes descriptions of the various equipment and systems with an orientation to promoting an understanding of what is involved in providing for their safe, reliable, and economical operation.

1.2 ORGANIZATIONAL CONSIDERATIONS

Operations, as used here, refers to the daily functioning of facilities. It is not normally an organizational entity within the plant department. Some of the

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Valuable research and technical information contributed by Charles Moody, Director of Physical Plant, University of Nevada/Las Vegas, and Thomas Vacha, Manager, Mechanical Operations, Massachusetts Institute of Technology.

functions that fall under the operations umbrella, such as the operation of building mechanical systems, are usually the primary responsibility of the maintenance division. Others, such as central control and automation or computerization of plant services, may be managed by the plant department's administrative division.

There is a trend toward concentrating the control and coordination of operations in an operations center—similar to an operations center of military units that controls all elements of the force. A number of factors have contributed to this development.

Continuous monitoring and emergency alarms have come into use that detect elevator malfunctions, fires, and violations of high security areas as well as monitor environmental conditions in sensitive research areas. These devices must have a central location at which alarms can sound and action be taken.

Another motivation for centralization is that malfunctions in central plants or utilities distribution systems must be reported quickly and corrective action initiated. In addition, the high cost of energy recommends close, uninterrupted control of energy conversion and consumption equipment. This need has led to the development of systems that permit control from a central point.

Most of these operational kinds of functions are not independent, but are interrelated. As a result, they can best be handled from a single location within the plant department. This location—staffed, organized, and equipped for handling many kinds of operational matters on a 24-hour basis—is commonly referred to as the plant department operations center.

The work control center, discussed in **Part III**: Maintenance Management, is usually a separate unit within the operations center. The functions of the two centers are separate and distinct, though they require close coordination. For instance, the operations center, which has responsibility for the functioning of the utilities systems, perhaps could best handle utility outages necessitated by maintenance work projects. The operations center may have responsibility for assembling crews for emergency work outside regular hours.

1.3 ENGINEERING REQUIREMENTS

In the past, the role of professional engineers in college and university plant departments was largely confined to the planning, design, and construction needs of new facilities or to major repair and alteration projects. Facilities operations was left largely to mechanics whose duties centered principally on startups, shutdowns, and corrections of malfunctions. However, several forces have recently combined to create an important role for engineers in the area of facilities operations.

One is the high cost of energy. High-priced energy has placed a priority on the optimum operating efficiency of equipment. When energy prices were low, minor inefficiencies had little effect on cost. For example, mechanics could adjust the fuel-to-air ratio for reasonably efficient combustion in a power plant on the basis of flame color. Due to today's higher energy prices, however, anything short of optimum power plant efficiency results in substantial additional costs. Simply looking at the flame color is no longer efficient. The same is true for all energy conversion, transmission, and consumption equipment. The continual monitoring, evaluation, and adjustment—directed and controlled by engineers—can be cost effective.

Another factor has been the improvement in equipment that often requires judgment, evaluation, and computation on the part of engineers. When energy was cheap, for example, factors unrelated to fuel governed the way that buildings were designed and operated. However, now that new and better equipment is being developed, it is important for efficiency of operation and life cycle costs to be carefully evaluated when both determining the optimum time for replacing equipment and selecting new machinery.

The advances in building technology are a third factor that has contributed to the need for engineers in operations. The growth in large central plants of all kinds, extensive distribution systems, and sophisticated environmental monitoring devices has fostered a need for engineering capabilities in facilities operations. As a result of these developments, mechanical and electrical engineers are becoming indispensable to the economical and efficient management of plant operations.

CHAPTER 2

Central Utility Plants

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2.1 INTRODUCTION

All colleges and universities need the five basic utilities services: electric power, heating and cooling, water supply, sewage treatment, and solid waste disposal. To provide these services means generating each utility from a raw resource and then distributing it to the point of use. Universities and colleges vary in the methods of meeting these utility needs, ranging from complete self-sufficiency to total purchase. Most larger institutions provide their own heating and cooling; generate some portion of their electrical needs; and purchase water, sewage treatment, and solid waste disposal from the nearby community. Smaller colleges and universities generally operate boilers in individual buildings to meet thermal requirements but purchase all other services. The discussions in this chapter apply to utility plants of all sizes, although certain equipment and processes will be found to be cost effective in only the larger central plants.

Many factors recommend continuous review of the operation of each utility system and of the economics of combining two or more into integrated systems. Utility plants are long lasting, and alterations involve large capital expenditures. Although new technologies made higher efficiencies possible, retrofitting plants prior to 1973 was of limited cost effectiveness due to the low cost of fuels. Increased fuel costs since then have made the purchase and retrofit of equipment and improved operating practices much more cost effective. The rate structure for purchased electricity, which includes an annual charge based on peak demand, prompts a closer look at campus on-site generation. Heat recovery from solid waste also becomes a more attractive option.

2.2 PURPOSE AND SCOPE

Since central utility plants are highly technical, it is expected that evaluations will be made by qualified engineers before major operating changes or capital expenditures will be made for efficiency improvements. This chapter reviews the more basic techniques and equipment currently available and includes an elementary discussion of their functioning. It is intended to help plant managers to better evaluate their energy improvement options and to better discuss equipment modifications with manufacturers, dealers, and consultants.

The discussion is devoted primarily to steam and electric power generation with limited treatment of chiller plants and heat recovery from solid waste. It is impractical to try to cover all types and variations of utility plants. Coverage must be limited to the more common techniques and equipment.

2.3 STEAM-GENERATING UNITS

The steam-generating unit proper is the boiler, which consists essentially of a burner, fire box, heat exchanger, and the means of creating and directing a flow of gases through the unit. All combustion equipment includes these essentials. Most also include some auxiliaries such as air preheaters, economizers, superheaters, fuel heaters, flame safety devices, and automatic flue gas analyzers.

2.4 FUELS

The normal range of heating values for various fossil fuels are as follows:

Natural gas	20,000-23,500	BTU/lb. (1,000 BTU/ft.^{3})
No. 1 fuel oil	19,670-19,860	" "
No. 2 fuel oil	19,170-19,750	" "
No. 4 fuel oil	18,280-19,400	" "
No. 5 fuel oil	18,100-19,020	" "
No. 6 fuel oil	17,410-18,990	" "
Bituminous coal	11,500-14,500	" "
Sub-bituminous coal.	8,500-11,500	" "
Lignites	6,300- 8,300	" "

Where there are significant daily and seasonal variations in power demands, the storage of coal is required. If coal is stored, spontaneous combustion is a hazard. Oxidation at the surface of the coal takes place at all temperatures, is exothermic, and is promoted by a rise in temperature. Spontaneous combustion is more likely to occur where there is a high percentage of combined moisture and a large amount of fine coal. The height of the coal dump should not exceed five meters in order to permit adequate ventilation.

2.5 BOILERS

The steam-generating units, or boilers, operate at varying efficiency plateaus and are produced in various configurations. What follows is a concise description of expected efficiency levels, types of equipment, and ratings.

Efficiency

Boiler efficiency is the percentage of the higher heating value of the fuel that is converted to steam. The predicted performance of each boiler can be found in the manufacturer's proposal information. In addition, a boiler efficiency measurement is normally included as a part of the acceptance test when the unit is installed. Efficiency can be expected to vary from 80 percent to about 87 percent, depending upon the fuel type and boiler type. Due to the unit cost of fuels and large heat flow rates, minor improvements in efficiency produce substantial cost savings.

Types

For the purposes of this discussion, boilers fall into two classifications: firetube and watertube.

- Firetube Boilers. In firetube boilers, the products of combustion pass through the heat exchange tubes, while water and steam are outside the tubes. Many boilers of this type are sold as packaged units mounted in a single framework. They are used primarily in heating systems, and are produced in sizes up to about 14,000 lb./hr. They are not used for turbine applications since they are not well suited to the installation of superheaters. The installed cost of a firetube boiler is considerably less than that of a corresponding watertube boiler.
- Watertube Boilers. In watertube boilers, the water, steam, or heat-transfer medium circulates through the tubes while hot products of combustion pass outside the tubes. Boilers of this type may be further classified as horizontal straight tube and bent tube. For pressures above 150 p.s.i. and over 15,000 lbs. steam/hr., the steel watertube boiler is used almost exclusively. Pressures in some plants are as high as 5,000 p.s.i. The watertube boiler is composed of tubes and drums—the tubes interconnecting the drums—which are for the storage of water and steam. The purchase price of the watertube boiler is higher than that of an equivalent firetube boiler, but its higher efficiency will eventually offset the higher purchase price.

Ratings

Power boilers are rated on the basis of boiler horsepower plus an overfiring rate, and by a steam flow rate.

Boiler horsepower is the transfer of 33,475 BTU/hr. As boiler efficiencies improved, the rating increased and the capacity was expressed as a percentage of the base, as "100 to 150 percent of rating, normal load range," or "200 to 250 percent rating, peak load range for two- to four-hour peak operation."

Steam flow rate is expressed as pounds of steam per hour or pounds of steam per hour per square foot of heating surface. When expressed in this manner, the feed water temperature, quality (steam dryness), steam temperature or degrees of superheat, and specified conditions of the fuel, fuel burner, firing method, and draft are required for an accurate rating.

2.6 AUXILIARY HEAT TRANSFER EQUIPMENT

Since the products of combustion cannot be cooled in a single unit to a temperature below that of the saturated water within the boiler but are always at a much higher temperature in order to have a considerable temperature difference, much heat is carried to the stack. To recover some of the heat, the following equipment may be added:

- Economizers consist of tubes placed in the path of the exit gases. The feed water is pumped through these tubes to the boiler. The heat thus recovered reduces the amount of fuel required.
- Air preheaters are used to circulate the combustion air through tubes in the path of the exit gases or through air-cooled walls of the furnace. This raises the temperature of the combustion air, resulting in higher temperature combustion.
- Superheaters direct saturated steam from the boiler through tubes over which the hot furnace gas flows.

2.7 FUEL HANDLING AND FIRING

The various forms of fuel require diverse firing methods. How the different fuels are handled and processed for combustion in boilers is highlighted.

Natural Gas Firing Natural gas is the simplest fuel to burn because it requires little preparation and mixes readily with the fuel combustion air supply.

Oil Firing Oil fuels generally require some type of pretreatment prior to burning, including removing of solids and heating to assure proper viscosity. They must be atomized prior to vaporization and mixing with combustion air. The oil is introduced into the burner as a fine spray.

Pulverized Coal Firing The pulverizer system works by pulverizing, drying, classifying to required fineness, and transporting the coal to the burner's mass air stream. Provision is made for controlling the furnace ash deposits and allowing sufficient cooling of the gases leaving the furnace to reduce the buildup of slag in the convective regions.

Stoker/Grate Firing Stoker firing methods include underfed, overfed, and spreader. With underfed and overfed stokers, coal is transferred directly onto the burning bed. In a spreader stroker, the coal is hurled into the furnace where it is partially burned in suspension before reaching the grate. Grates come in several forms—stationary, chain, traveling, dumping, or vibrating. For optimum operation, each type requires different degrees of coal fines and ash characteristics. Spreader stokers have the advantage that they can burn a wide variety of fuels. Underfed and overfed units have the disadvantage that they are slow to respond to load changes.

Fluidized Bed A new way of burning solid fuels is in a bed of inert material such as sand or ash. Combustion air flows in such a way that the solids-air mixture behaves like a fluid. The system promotes a high degree of mixing and thus high temperature burning. Another of its assets: It can handle low-grade coals with high ash and sulfur concentrations due to the low bed temperature.

2.8 COMBUSTION CONTROL SYSTEMS

Combustion controls have two purposes: to adjust the fuel supply in order to maintain the required steam flow or pressure under varying loads, and to maintain the optimum ration of combustion air to fuel. There are three basic control systems, each with variations: on-off, positioning, and metering.

On-Off Control System

On-off control is generally regulated by a steam pressure-actuated switch. When the pressure drops to a preset level, fuel flow is increased and the operation then continues at a constant level until the pressure rises to a preset level. This type of control is generally used for firetube and the smallest watertube boilers.

Positioning System

Positioning controls also respond to steam pressure. But in this system, the controller responds to changes in the steam drum or header pressure by positioning fuel supply valves and forced draft dampers. These types of controls are used on single-burner boilers and are restricted to systems that burn one fuel at a time. There are three types of positioning controls:

- Fixed positioning. A single actuator moves both the fuel and air controls to preset positions through mechanical linkages. This system cannot compensate for changes in fuel or air density, or fuel supply pressure, so controls are normally set for high excess air to guard against dropping below the minimum excess air requirements.
- Parallel positioning with operator trim. Pneumatic or electronic positioning of the fuel and air supply controls are actuated by a single pressure controller. A combustion guide is required to enable the operator to position the excess air flow. This is the most widely used combustion control for units below 100,000 lb./hr.
- Pressure ratio. A parallel pneumatic or electronic system is used with the wind-box-to-furnace/burner pressure ratio to trim the fuel and air flows. Manual controls to change both the ratio of pressure and excess air flows are normally provided, along with a combustion guide.

Metering System

In a metering system, the fuel and air flows are metered and the fuel supply and air supply controls are modulated in accordance with the measured flows. This kind of combustion control apparatus is restricted to fuels that can be accurately metered. A refinement of this system is cross-limited metering, which limits the change in fuel flow through control logic to available air flow at all times. The air flow is also tied to the fuel flow. The system can be further refined by using a continuously monitored flue gas analysis and by trimming the fuel-to-air ratio based on the oxygen content. This compensates for variations in fuel heating values and combustion air conditions.

2.9 PRINCIPLES OF COMBUSTION

Combustion of all fossil fuels is the oxidation of carbon and hydrogen to form carbon dioxide and water. If there is a lack of oxygen, some of the carbon will not be completely oxidized and carbon monoxide will be formed. Carbon monoxide is itself a fuel with a heating value of about 4,300 BTU/lb., so its formation indicates incomplete combustion of the fuel. The products of combustion may also include nitrogen and sulfur oxides, which it is important to note, are air pollutants and can cause chemical fouling of boiler equipment.

The quality of combustion is a factor to be considered. Three conditions must be met for combustion to occur:

- The fuel must be gasified.
- The oxygen-fuel mixture must be within the flammable range.
- The mixture must be above the ignition temperature.

Once the combustion process is started, the quality of combustion is determined by time, temperature, and turbulence. Good combustion is rapid, has a high flame temperature, and is turbulent. Turbulence is the key factor in boiler furnace combustion. If turbulence is high, mixing of the oxygen and fuel will be good and combustion will be rapid and result in a high temperature.

The specific amount of air required to complete combustion is known as "theoretical air." In actual combustion, an excess amount of air is required because the mixing of fuel and air is never perfect. The amount of excess air depends upon the boiler type, fuel properties, and burner or stoker characteristics. Since excess air is supplied to the combustion process, all the available oxygen in the air will not be used. Excess air requirements are stated as a percentage, as is the excess oxygen in the flue gas.

To measure the percent of excess oxygen in combustion products, an oxygen analyzer is used. From the measured excess oxygen and known chemical composition of the fuel, the excess air can be determined. Measuring oxygen is generally preferred to measuring carbon dioxide because the instrumentation is simpler and cheaper, and the oxygen-to-excess air relationship is more invarient than is carbon dioxide to air.

2.10 COMBUSTION OF SPECIFIC FUELS

Various fossil fuels burn more cleanly or more easily than others. The different fuels form varying combustion products. Summarized below are the fossil fuels commonly burned in boilers and their combustion qualities.

Natural Gas Natural gas contains 25 percent hydrogen and 75 percent carbon by weight. It is the cleanest burning and easiest to handle of all fuels. Products of combustion include water, carbon dioxide, hydrogen, oxygen, and nitrogen oxides.

Oils Firing of oil is more complicated than natural gas because of the fuel preparation required. For instance, oil must be heated in order to be pumped into the burner where it is atomized. Upon atomization, it vaporizes and burns. The carbon-to-hydrogen ratio is about 88 percent to 12 percent, with traces of nitrogen and sulfur. Products of combustion include water, carbon dioxide, nitrogen, oxygen, nitrogen oxides, sulfur, and particulate matter. The particulate matter sticks to tubes and boiler surfaces and leads to boiler fouling if not cleaned regularly. Sulfur oxides combine with water to form sulfuric acid, which is the major cause of boiler corrosion.

Coal In a coal-burning system employing stoker/grate firing, air is supplied to the combustion process in two parts. Primary air is first admitted through the fuel bed and secondary air is later added above the bed. The primary air ascending through the fuel first comes into the oxidizing zone, where practically all the oxygen is consumed in forming carbon dioxide. This inert gas then rises through the reducing zone, which extends to the surface of the fuel bed and in which a portion of the carbon dioxide is converted to carbon monoxide by reacting with the carbon. This combustible gas then passes into the combustion space above the bed where secondary air is admitted and the combustion process is completed. As a general guide, about half the air by weight is supplied through the bed and half above the bed. The rate of burning is controlled by the primary air, and the completeness of combustion by the secondary air. The products of combustion will vary with the grade of coal, but include carbon, hydrogen, nitrogen, oxygen, quantities of sulfur (0.5 percent to 3 percent), moisture (3 percent to 21 percent), and incombustible materials (4 percent to 10 percent) as well as nitric and sulfur oxides.

With a coal-burning system using pulverized coal, the primary air carries the pulverized coal into the furnace. Secondary air is then admitted to provide more oxygen for combustion and to stabilize the flame. Often tertiary air is introduced at some point remote from the main combustion zone in order to complete the combustion process. The principal advantages of using pulverized coal over other types of coal are (1) capability for better mixing of the fuel and air, which permits the use of less excess air; (2) ability to burn the fuel at high rates under the boiler; (3) flexibility of control, which permits quick response to changing requirements; (4) minimization of fuel waste in starting, banking, and other steps; and (5) the ability to maintain high rates of operation without forced draft due to the absence of a thick fuel bed.

2.11 BOILER EFFICIENCIES

Three major groups of heat loss factors affect boiler efficiency. They are combustion factors, heat transfer factors, and steam loss factors.

Combustion Factors

The many sources of heat loss in steam generators fall into three categories: stack gas waste heat, combustible losses, and radiation losses. Boiler efficiency can be improved by trimming these losses.

Stack gas waste heat exists in two forms: dry gas loss and moisture loss. Dry gas loss is the unrecovered sensible heat energy contained in the hot flue gases, excluding water vapor. Moisture loss consists of both latent and sensible heat of the water vapor resulting from the combustion of hydrogen, and any moisture present in the fuel or combustion air.

There are two fundamental methods of minimizing stack gas losses. One way is to reduce excess air to the minimum. This is the most effective technique that can be employed without high capital cost. Reduction of the excess air accomplishes two things: The amount of air in the flue gas that can absorb heat is lessened and the flue gas velocity is reduced, thereby increasing the heat transfer to the water or steam. Excess air can be reduced by modifications to the fuels, burner, or stoker. This is normally achieved by better mixing of the fuel and air.

An alternate method is to achieve greater heat recovery from the stack gases. Care must be exercised, however, in reducing stack temperatures with economizers, air preheaters, and other auxiliaries because reduced stack temperatures may lead to condensation of the water vapor. The water vapor, in turn, can combine with sulfur to form corrosive "acid rain" in the stack.

Combustible losses, evidenced by combustibles in the ash or other signs of incomplete combustion, can be reduced. These losses normally occur in the form of solid combustibles in the ash, carbon carryover in the fly ash, carbon monoxide, and unburned fuel. The corrections of this condition, for each fuel type, follow.

Natural Gas Carbon monoxide is the only combustible normally formed. It results from too little or too much excess air from insufficient mixing or from flame impingement on cold water walls. Certain remedial measures can be used. For instance, care should be taken to ensure that the burner is operating in the acceptable excess air range, that diffusers and other mixing equipment are operating properly, and that the flame shape prevents impingement.

Fuel Oil Carbon monoxide is formed by the same factors as for natural gas, and the corrections are the same. Additionally, the incomplete combustion resulting in carbon monoxide formation may result from improper oil viscosity and inadequate atomization. To correct these conditions, check and adjust the oil temperature and the operation of the diffuser and atomizer.

Pulverized Coal Carbon monoxide and carbon carryover may be formed by the same factors affecting combustible formation in natural gas, and can be corrected in the same way. Additionally, the incomplete combustion can result from variations in coal sizing. Check to ensure that sizing is correct, generally 70 percent through a 200-mesh screen.

Stoker-Fired Coal Without careful monitoring carbon monoxide and smoke may be formed by too much or too little excess air or low loads. Correcting the supply of excess air, increasing overfire air velocity, and shifting loads from other boilers may overcome the problem.

With stoker-fired coal, solid combustibles are always present in the fly ash, but the amount of unburned material can be reduced. Cutting down on solid combustibles in the fly ash can be accomplished by reducing the excess air, which, in turn, decreases the particulate and carbon carryover. Carbon carryover can be diminished by fly ash reinjection, but reinjection will normally increase the particulate loading at the stack.

Carbon monoxide, carbon carryover, and/or clinkers may result from too many fines, wet fines, insufficient bed thickness, improper undergrate air distribution, or improper feeder adjustments on spreader stokers. Plant engineers should check for proper combustion conditions.

Radiation losses result from heat that escapes through the boiler jacket. This loss constitutes a higher percentage loss at low-load conditions and with smaller boilers because of the increased surface-to-volume ratio. Radiation losses can be cut by ensuring that both the boiler jacket and duct work are in good condition.

Heat Transfer Factors

Deposits inside and outside the heat transfer tubes act as insulators that impede heat transfer. When deposits accumulate, less heat is able to be absorbed by the water or steam. The condition can normally be detected by monitoring flue gas temperatures. Rising temperatures indicate that less heat is being transferred in the boiler and more is lost to the stack. Improper combustion can speed soot deposits on boiler tube surfaces. Several steps can be taken to counteract buildup. The watertube boilers should, for instance, be subjected to frequent soot blowing, sometimes as often as three times a day. Water side deposits can be controlled by effective water treatment and by mechanical or chemical cleaning.

Steam Heat Loss Factors

Steam heat losses can result from faulty steam traps, leaks to the environment, and inadequate insulation. Of the three, malfunctioning steam traps may be the most important. A variety of equipment exists for detecting faulty traps: temperature-indicating crayon, temperature-actuated color-changing tape, surface temperature gauges, and ultrasonic detectors. Line losses should be checked and the cost effectiveness of added insulation recomputed periodically as energy costs rise. The amount of insulation is determined when steam lines are installed. based on cost effectiveness. However, increases in energy costs change the incremental cost-versus-benefit relationship, and at some point it may be cost effective to add insulation.

2.12 ON-SITE ELECTRIC POWER GENERATION

There are numerous types of electric power generators. Electric generators on college and university campuses, however, are usually the rotating type, driven by a prime mover. The more common prime movers are steam turbines, gas turbines, and diesel engines. Small plants cannot compete with large power-generating units operated by electric utility systems unless there is a use for the exhaust heat from the prime mover. It is by combining thermal and electric systems, called cogeneration, that greatest efficiency can be realized.

All thermodynamic systems have the potential for performing a maximum amount of work in reaching equilibrium with the environment. The maximum quantity of work is achieved in going from the initial state to a final state through reversible processes of heat transfer and work. For example, steam turbines operate with throttle temperatures of about 1,000°F, and combustion turbines with inlet temperatures in the 2,000°F range. Thermal energy in the range of 100° to 400°F is required for space heating. By incorporating turbines into the system to generate electric power, more complete use of the energy in the steam can be achieved than in a conventional heating plant that generates steam to meet only the thermal loads. The system that will provide the highest efficiency is one in which the power generation system is chosen on the basis of optimum size to provide exhaust heat for meeting the thermal requirements. Any smaller power generation results in using conventional boilers to produce additional hot water or low-quality steam for heating and cooling. Any larger unit results in a portion of the on-site electric generation system competing with the high thermal efficiency characteristics of large power-generating units of utility companies.

In a cogeneration system, the lower the steam pressure in the steam distribution system, the greater the electric generation. For example, when the exhaust pressure is 125 p.s.i., only about half the nominal annual average electrical energy can be generated while supplying the thermal loads. More electric power can be produced by adding a condensing section to the turbine, but approximately 50 percent of the additional fuel energy supplied to generate the increased electrical power would be lost to the condensing water.

In summary, the production of electric power for which the turbine exhaust steam can be used is highly favorable from an energy efficiency viewpoint. Where possible, the thermal distribution system supply temperature and pressure should be lowered to allow greater electrical power production at the favorable heat rate.

2.13 CENTRAL CHILLER PLANTS

Cooling loads peak in the summer. If electric motor-driven centrifugal chillers are used, the peak electric demand by these machines will occur during the summer when the minimal heating loads dictate the minimal electric generation at the high-efficiency heat rate. If absorption chillers are used, there is less electric demand and more use of the exhaust heat from power generation.

It is imperative that usage patterns and loads be closely examined to determine the maximum demands and equipment size. A detailed analysis of the instantaneous loads is required to determine the annual savings for a given system. Part-load equipment performance and particular combinations of utility service demands can have major effects on savings realized.

Campus cooling systems typically consist of window air conditioners, other air-cooled direct expansion equipment, and water-cooled chilled water systems. Generally, the air-cooled direct expansion equipment is less efficient than chilled water. Optimum economies can often be realized by maximum use of absorption refrigeration during periods of high load and high electric demand, and use of electric refrigeration to a greater extent during partial load conditions.

For the construction of new campuses, central chilled water generation is generally the most cost-effective solution to providing primary cooling. The efficiency of the large equipment tends to offset the initial cost for distribution systems. Maintenance considerations weigh in favor of centralization as well. However, replacing the equipment of a decentralized system, once installed, cannot be justified solely on the basis of energy efficiency. But it is advantageous to plan for future replacement of individual units of a decentralized system, when required, with higher efficiency equipment in a central plant. A chilled water loop is an interim step in such a transition.

A chilled water loop system to integrate the systems of several buildings can produce immediate savings. As individual chiller systems require replacement, their capacity need not be duplicated in an existing location. Instead, planning for the equipment replacement in a central location will allow for the use of larger and more efficient equipment and more convenient maintenance.

2.14 HEAT RECOVERY FROM SOLID WASTE

The recoverable energy from incineration of solid waste is generally less than 10 percent of an institution's requirement for heating and cooling. Thus solid waste from surrounding communities may be used as supplements to increase the institution's quantity of recoverable energy.

The simplest approach to heat recovery from solid waste is to produce low-quality steam for heating and cooling. This proves most satisfactory when the prime mover for electric generation is a diesel or gas engine and there is, consequently, a deficiency in the thermal energy available from the exhaust. Modular incinerators are normally operated on a 24-hour schedule with up to ten hours burn time.

Low-pressure steam from an incinerator heat recovery boiler cannot be as effectively used when the prime mover for power generation is a steam turbine. If the thermal-electric requirements have been balanced to load requirements, the use of heat from another source would displace the waste heat available from power production. This would then reduce the amount of electric power that can be produced at low heat rates. One effective method to recover energy from solid waste is to preheat the boiler feed water in an economizer. An alternate scheme is to cofire the solid waste in a power boiler capable of burning solid fuels. Care must be exercised in combining heat recovery from solid waste with the production of steam for electric power generation. The heating value of the solid waste is often assumed to be totally recoverable, and the cost effectiveness of such a plant is calculated accordingly. The practical realization of this economy in an operating system normally falls short of this optimum. Nowhere is a careful analysis and design by qualified engineers required more before making capital expenditures than on such a plant or equipment.

CHAPTER 3

Utility Distribution Systems

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3.1 INTRODUCTION

The basic utilities required by colleges and universities, it was noted in Chapter 2, "Central Utility Plants," must be produced from raw resources and distributed to the point of use. The information also revealed that institutions vary from complete self-sufficiency to total purchase of utilities. Whether they produce or purchase utilities, however, most institutions own and operate systems for distributing one or more utilities. Of these, electric and steam distribution systems are the most common.

Utility distribution systems are highly technical and require competent engineering in design and operation in order to achieve efficient transmission and safe usage. Good engineering also protects the equipment from damage and assures reliability of operation. Detailed data on the individual components of distribution systems can be found in technical publications. What this chapter presents, however, is a comprehensive general description of the components and operating systems along with an exploration of the major potential problem areas. These overviews are intended to assist the nontechnical manager in carrying out supervisory and coordinating responsibilities as well as to provide organization and guidance to the technical personnel in operating and maintaining systems. Detailed information on maintenance programs is contained in Part III, "Maintenance Management," of this book.

Detailed descriptions of the two most common utility distribution systems—electric and steam—are presented in this chapter, with a lesser treatment of water. Other utilities are more commonly furnished and distributed by local community systems.

Our use of the term distribution systems encompasses all transmission equipment that is used from the point at which the utility is received by the institution's systems to where it enters each campus building. Since electric power and steam are typically transmitted at higher voltages and pressures, respectively, than those at which they are used, the division between the distribution system and the building system is normally marked by the point at which "stepping down" occurs.

3.2 ELECTRIC DISTRIBUTION SYSTEMS

Electricity is a unique utility in that it must be used at the instant it is generated. It cannot be stored or stockpiled to meet future requirements. Generating capacities must, as a result, be able to meet instantaneous peak load requirements. From the installation of the first system to sell lighting to New York City in 1882, this characteristic created two problems: how to deal with the voltage drop that took place during transmission over long distances and how to meet widely varying voltage requirements. The resolution of these two problems by use of high-voltage alternating current and through the development of the transformer made possible efficient distribution systems that would meet wide-ranging customer requirements. It also led to the phenomenal growth of the electric industry.

Although simple in basic concept, today's electric distribution equipment and systems are characterized by highly sophisticated technologies that continue to develop rapidly. Since electricity is invisible and its effects are not readily apparent, a mathematical approach is needed to achieve a full understanding of the design and operation of modern distribution systems. This requires highly technical training and is beyond the scope of this book. Rather, the text intends to describe the physical devices, their purposes, and their relationships in order to promote a more general understanding of the systems.

The electric distribution systems described here refer to university-owned facilities at which electricity (whether generated on campus or purchased, or both generated and purchased) is received and is further distributed to points on campus. Situations in which a municipally or commercially owned electric utility entity furnishes electricity in utilization voltages to buildings, however, are not covered in the discussion.

Anatomy of an Electric Distribution System

College and university electric distribution systems generally consist of the following: a switching station that is the receiving area for electricity prior to distribution, switching substations, high-voltage conductor circuits, transformers, and system protection.

Switching Stations Switching stations perform a number of principal functions. For example, they switch electric power from a larger transmitting system to the college or university system and then switch the electric power that is generated on campus into the system. A switching station will normally either have more than one feed, or there will be more than one station serving the college or university system—each with a separate feed. The station provides for switching between feeds as necessary.

The switching station reduces high-voltage electricity from the incoming system to the voltage that is required by the college or university system. Electric power is regularly transmitted over long distances at high voltages, usually over 30,000 volts. University systems, for reasons of safety and economy in equipment costs, usually operate at lower voltages. The transformers in the switching station, then, cut voltages to levels at which a university or college system is designed to operate.

Finally, the switching station houses fault detection and circuit interruption facilities to protect the institution's system from exterior faults and overcurrents.

Switching Substations Substations in the institution's distribution network perform functions similar to switching stations. They handle the switching of the electric service from the supply mains of the switching station, usually located on the campus periphery, to feeders that supply campus areas. They contain sectionalized assemblies of switches, circuit breakers, and metering equipment that control and monitor electrical service to the feeders, which, in turn, supply individual buildings. Substations may house transformers for stepping down power to utilization voltages or to an intermediate voltage.

High-Voltage Conductors and Circuits There are two basic circuit systems for feeding from the substations to building systems: the radial system and the network system. The radial system is one in which separate feeders radiate out from the substation, each supplying an area. From these feeders, subfeeders or branches split off to transformers serving individual buildings or a cluster of buildings. The radial circuits are equipped with tie switches so that, in event of a fault, the circuit can be supplied by another feeder. Radial feeders with loop or throw-over switching are most commonly employed.

In the network system, the secondaries of two or more transformers are tied together. Adjacent transformers may be supplied from the same or different feeders. Distribution, therefore, is normally at utilization voltages.

Three principal factors determine the distribution voltages. First there is the trade off between the cost of energy loss in transmission and the cost of transmitting equipment. For a given percentage energy loss in transmission, the cross section and consequently the weight of the conductor required to transmit a block of power vary inversely as the square of the voltage. Thus, if the voltage is doubled, the weight of the conductor will be reduced to one-fourth with approximately a corresponding cut in cost. Therefore, in the design of a system or component of a system, the required installation and maintenance cost must be compared with energy losses to determine the optimum distribution voltage.

Available voltage is another key factor in determining distribution voltages. There is an advantage in being able to make a direct tie to what is available. The voltage selected for generation in power systems, including on-campus generation, is almost invariably 13,200 to 14,400 volts.

The strength of conductors also figures in. Overhead transmission lines must be strong enough to carry any load that may be reasonably expected. The most severe loads are experienced during low winter temperatures with resulting ice and wind. Underground conductors must be able to withstand allowable stress to which the cable may be subjected during installation. Thus the need for adequate physical strength of a cable will help determine its electrical conductive capacity.

At some point a decision must be made as to whether to use overhead or underground transmission lines. Underground transmission lines are generally installed in ducts that run from manhole to manhole. The manholes, which are used to replace sections of cable, are spaced as far apart as possible while permitting allowable stress in drawing the cable into and out of the duct. The number of manholes needed, consequently, varies inversely with the size of the cable. The larger the cable, the fewer the manholes.

Underground conductors must be electrically insulated from the return or other circuits and need to be protected from moisture. Overhead lines, on the other hand, are more vulnerable to mechanical damage but do not require insulation.

When comparing costs on overhead or underground transmission lines, it should be noted that the cost of underground construction is much higher. However, overhead lines are unsightly and detract from an attractive educational environment. They also create problems of routing to building transformer vaults that are often located in basements. As a consequence, underground transmission lines are most commonly used in new installations.

Transformers Differing generation, transmission, and utilization requirements dictate different optimum values for voltage and current combinations. There arises, consequently, a need for a component that is capable of changing or transforming voltage and current at high power levels in a reliable and effective way. This is the function of the power transformer that is an extremely important link between the transmission of electric power and its use. Transformers make it possible to generate energy at any suitable voltage (such as 13,000 to 14,000 volts), change it to much higher voltage (such as 100,000 volts) for transmission over long distances, and then deliver it to a college or university distribution system at still another voltage.

All transformers have certain basic elements. The essential elements are (1) two or more windings insulated from each other and from the core and (2) a core that is usually made of thin, insulated, laminated sheet steel. Power transformers that are used for stepping down the voltages in an institution's distribution system are classified according to type of core construction and type of cooling employed.

Two types of core construction are used: core and shell. In the core type, the magnetic circuit comes in the form of a single ring with the primary and secondary windings encircling the two legs of the core. In the shell type, the relative positions of the coils and the magnetic circuit are reversed. Here the winding forms a common ring in which two or more magnetic circuits are interlocked.

College and university systems use transformers that are either air- or oil-cooled. The air-cooled variety uses air ducts that lead through windings and the core. The transformer is surrounded by a thin sheetmetal case that is open at the ends and through which air is circulated by means of a fan or blower. An advantage to air-cooled transformers is their low cost. With the oil-cooled type, on the other hand, the windings and core are mounted in an oil-tight steel tank. The tank is filled with a high-quality oil that conducts heat to the case. The oil also serves as additional insulation between windings and between windings and core. In larger transformers, the tank surface is corrugated or finned to promote better heat transfer.

Power can be transformed in stages. If substations are used, common practice is to step down the voltages in two phases: once at the substation and again in the transformers for each building. The primary determining factor is, again, the trade off between conductor cost and energy losses. This trade off may dictate a different cable size for the feeder circuits than for the primary feeder to the substation. In such cases, the voltage is stepped down at the substation for transmission to building transformers where it is further reduced to utilization voltages.

Depending on their intended use, transformers will be located in different areas. Transformers used to reduce power to utilization voltages are typically sited in building vaults or on fenced exterior concrete pads. Due to vibrations in the laminated core, transformers may emit a high-frequency hum. This constant monotonous noise can be objectionable in the learning environment of a college or university. Care should be taken, consequently, to insulate occupied facilities from transformer noise.

System Protection The normal operating mode of a power system is balanced three-phase alternating current. A number of undesirable but unavoidable incidents can temporarily disrupt this condition. These include faults, as described in Chapter 4, "Building Mechanical and Electrical Systems," and load-induced overcurrents. These occurrences disrupt the transmission system through one or more of the following ways:

- Allowing large currents to flow, which can damage equipment.

- Causing electrical arcing, which can start fires or damage equipment.
- Raising or lowering system voltage outside acceptable ranges.
- Causing a three-phase system to become unbalanced, which in turn causes three-phase equipment to operate improperly.
- Interrupting the flow of power.

The protection of a high-voltage system is designed to safeguard the system and accomplish some specific actions. For instance, it works to detect and isolate faults instantaneously. It keeps as much of the system in operation as possible. It restores the system as soon as possible. And lastly, it discriminates between normal and abnormal system conditions so that protective devices will not operate unnecessarily.

There are three types of components of a protection system: detection devices, relays, and circuit breakers.

Detection devices detect faults and other abnormal operating conditions by the continuous measurement of current, voltage, power, and impedance. The measurement of current and voltage supplies the information required for determining power and impedance. Continuous monitoring is performed by instrument transformers: voltage (or potential) transformers and current transformers.

Relays are devices that, based on information received from the detecting equipment, perform switching action. Relays must have the following characteristics:

- Reliability. They may be idle for several years, then suddenly be required to operate with quick response.
- Selectivity. They must not respond to abnormal but harmless system conditions such as sudden changes in load.
- Sensitivity. They must be responsive enough to perform in every case required.
- Speed. They must make decisions and respond quickly.

Circuit breakers are mechanical devices that are capable of breaking and reclosing a circuit under all conditions, even when the system is faulted and currents are at greatest values. When high-voltage contacts part, an arc forms. The circuit breaker must extinguish the arc quickly. In addition, it must have the capability to rapidly force apart heavy contacts. The breaker must rely on a mechanical force to break the circuit since, at the time breaker action is needed, the electric system is unreliable. Circuit breaking is accomplished by releasing a mechanical latch and enabling a coiled spring or a weight to open the contacts. There are two principal types of high-voltage circuit breakers.

One type is the oil breaker. With oil breakers the arc, at the time of current interruption, is quenched in oil, which is totally enclosed in a steel tank. Oil breakers have limited interior use due to fire hazard but are widely used outdoors.

Air blast, or magnetic blowout breakers are a second form of circuit breaker. Here the arc is quickly forced into an elongated path by interaction with a magnetic field or by a stream of compressed air.

In distribution systems, circuit breakers often have built-in instrument transformers and relays. They are called reclosers. Some faults are self-clearing if the circuit is deenergized for a short time. The recloser operates to deenergize the system for a short time and then recloses it. If the fault persists, it again deenergizes the system and recloses. Reclosers are normally set to repeat the cycle three times after which they will lock open until manually reset.

With high-voltage circuits, using fuses is an inexpensive method of system protection. However, fuses cannot be recycled and thus require replacement after one operation. They therefore lack the reclosing capability of circuit breakers.

Power Factor Correction

Power factor is an important value in load consideration and measurement. Alternating current was adopted principally to take advantage of transformers that do not operate with direct current. It also helped to simplify motor design. At the same time, problems were introduced by the presence of inductive reactance in the circuit and reactive power required by motor loads. Because of the reactive power, principally in motors but to some extent in other loads, the current lags in time relative to the voltage; therefore, more current is required to provide a given amount of power. The power factor is the quantity by which the apparent power must be multiplied to obtain the active power of the circuit. There is no way to eliminate this component of current, but it can be counteracted or neutralized by adding another load to the circuit in the form of capacitors. Capacitors can be located at the loads, in the substations, or on the lines. Power factor correction on the lines is generally less costly.

Load Limiting

There are many variations on the specific methods for computing electricity costs, and some are complicated. But virtually all systems are based on two factors: total watt-hours usage and maximum demand over a limited time period. Since the annual rates are based on the maximum usage during a prescribed time period at any given time of the year, an unusually high load for a short time can result in a substantial cost increase. To stay within the designated demand limit and to ensure continuous service to high-priority facilities such as medical centers and research laboratories, a load-shedding schedule must be developed that sets priorities for dropping loads off the system. Continuous monitoring of usage permits immediate load shedding when it becomes necessary.

3.3 STEAM DISTRIBUTION SYSTEMS

Steam distribution systems are the networks that supply heat to a campus. The pros and cons of the principal methods used at institutions are addressed.

Central Generating Plants Versus Building Plants

Two major methods of supplying steam to campus facilities are to use central generating plants or to use a decentralized approach with individual building plants. Cost and value comparisons of heating methods that use a central steam generating plant against those that rely on individual building plants are complex and require a careful consideration of many factors. For example, central plants are cheaper to install, require less labor to operate and maintain, and consume less fuel than heating plants that are housed in individual buildings. The economic advantages of cogeneration, in which the exhaust from the turbines driving electric generators is supplied to the heating system, are described in Chapter 2. Using a central plant frees up space in buildings that would otherwise be used for generating equipment. The central system favors value factors such as aesthetics, reliability, safety, and minimization of noise and air pollution. But while most factors favor the central plant, the need for a distribution system to deliver steam to each building at the temperatures and pressures required is a major factor that must be weighed in any comparative evaluation. When looked at in this light, it is found that some drawbacks to the central plant exist. For instance, when steam travels through distribution mains, there is a loss of heat and a drop in pressure. In addition, the cost of mains and their installation limits the radius that can be served with practicality. However, a distribution radius of one mile or more is not uncommon.

A steam distribution system must accomplish certain operations efficiently. For example, a distribution system must be designed to supply steam to individual buildings at temperatures and pressures required, return the condensate to the central plant, protect the piping from mechanical damage and corrosion, provide for pipe expansion and contraction, and prevent excessive heat loss. The equipment and methods used to accomplish these steps are presented below.

Distribution Piping Systems

A campus must provide facilities to handle heavy pedestrian traffic, parks and plazas for student assembly and interaction, and limited vehicle traffic.

At the same time the campus must serve as an attractive learning environment. These considerations virtually require that steam distribution systems be installed underground. Three kinds of underground steam piping systems are in use on campuses. They are tunnels that connect buildings, proprietary-type conduits, and jobsite constructed conduits.

Tunnels serve the functional requirements of a steam distribution system best. For example, the piping is accessible for inspection, repair, replacement, or expansion. It is also protected from most hazards. Tunnels require ventilation, illumination, water drainage, and adequate service openings for personnel and equipment. In addition, isolation barriers are required to localize hazards to personnel from high-pressure steam that escapes. The same piping practices should be used in tunnel passages as for conventional buildings.

Proprietary systems are another form of underground steam piping system used on campuses. Prefabricated underground conduits consist of the carrier pipe and thermal insulation that are assembled with pipe supports in standard pipe lengths. The manufacturer submits precise layout drawings for the institution's approval before fabrication. Expansion loops, bends, and anchors are fabricated for assembly on site. Coupling materials and insulation are provided. Sometimes one or more pipes may be installed in a single casing, but the usual practice is to separate the piping for greater reliability. The systems on the market differ primarily in the kinds of external casing material used. Metallic casings—which include corrugated and smooth steel and cast iron—must be coated for protection from corrosion. Nonmetallic types come in glass fiber, reinforced polyester resin, asbestos cement, and polyvinyl chloride plastic.

Field fabricated proprietary underground conduits include concrete insulation encasement (which provides thermal insulation and pipe protection), thermal setting insulation, specially prepared tiles, and urethane foam. The trenches that hold the prefabricated conduits must be cleared of rocks and graded to the proper slope. In addition, a sand bed may need to be laid to ensure uniform bearing. To accommodate differential expansion between the pipe and surrounding materials, a parting agent should be used around the pipe that permits longitudinal movement.

Jobsite constructed conduits are a third type of underground steam piping system. They come in two principal forms: concrete box (or chase) and hydrocarbon fill. With the concrete box variety, multiple pipes may be installed in suitable supports. Removable covers are placed over the chase. To keep corrosion in check, ventilation and water removal are needed at the low points. With the hydrocarbon fill type, the granular hydrocarbon material is compacted around the pipe. The fill is thermoplastic, softening with increased temperature and consolidating underground pressure. Given time and interaction with the temperature, the volatiles that provide initial plasticity are driven off, leaving a hard coal-like mass.

Basic Maintenance Strategies

Corrosion is always a problem in steam piping. If uncontrolled, it causes rapid deterioration, particularly in condensate return lines. Corrosion can occur on the inside or outside of pipes. The greatest corrosion occurs inside the pipe because of acidity and the presence of oxygen. Chemical treatment and deaeration of the boiler feed water help limit this corrosion. External pipe corrosion, on the other hand, is caused predominantly by ground water. To combat the effects of ground water, three steps can be taken. First, provide good surface drainage to reduce the amount of ground water. Secondly, provide drains in the conduits where possible. Third, use external waterproof casing to protect the insulation and pipe. Insulating materials are generally porous. Thus if water is present in the ground and penetrates the casing, it will reach the surface of the pipe.

Protecting underground piping from mechanical damage means protecting it from superimposed loads. When depth of burial is determined by the frost line, adequate bridging over the conduit is required to protect it from surface loads such as vehicles and building or street curb footings. Maintaining up-to-date drawings of underground steam piping helps guard conduits against damage from excavation equipment.

Pipe Insulation

Insulating materials that are used for underground piping are calcium silicate molded pipe covering, preformed fibrous glass, cellular glass, lightweight concrete, asphaltic-bound lightweight aggregate, hydrocarbon granular fill, and urethane foam. Each insulating material has its own characteristics in terms of thermal conductivity, moisture absorptiveness, chemical compatibility, combustibility, comprehensive strength, density, flexural strength, resistance to abrasion, temperature limits, and shrinkage. Therefore, it is best to match each specific situation with the most appropriate material. The thermal conductivity of the ground depends primarily upon the moisture content. For dry soil it is about 2 to 3 BTU/hr/°F/sq.ft./inch. For wet soil it is about five times higher. Moisture has a similar effect of increasing the conductivity of manufactured insulating materials.

Pipe Installation

Before installing piping, it pays to know the pluses and minuses of each type. Except in tunnels, underground piping is not readily accessible. Types and thicknesses of piping materials should be selected for durability and capability for handling possible increases in operating pressures. Proper joining of the piping is critical since connections also serve as structural joints that transmit expansion and contraction forces. For steel pipe, welded construction is usually considered mandatory. When selecting pipe for the condensate return line, take into account that the condensate return line is subject to internal and external corrosion more than the steam supply line.

Steam piping systems can be expected to experience movement due to thermal expansion and contraction. This movement must be accommodated to protect elements of the system from damaging forces. Protection can be accomplished by using the pipe's flexibility for bending or by inserting expansion joints. The expansion devices should be spaced at intervals of 60 to 300 feet, depending upon the kind of pipe and expansion joint used. Three kinds of expansion systems are described.

One method of accommodating pipe movement is the placement of bends in the pipe. In bending, axial movement is accommodated by connecting the two offset pipes in either a "Z" shape or a complete loop. The space available for lateral pipe movement coupled with the complicated design of the underground piping system it creates are two factors to keep in mind when considering bending as an expansion method.

The sliding joint method uses piston or sleeve expansion joints. They require accurate installation, close alignment of piping, and frequent inspection. This type of joint is well suited to systems that cycle frequently.

Ball or swivel joints, the third type, are spherically gasketed pipe connections that permit angular or torsional rotation of the two connected pipes.

Pipes that are subject to expansion and contraction require anchors to divide the line into individual expanding sections. The anchors limit the amount of movement that the expansion device located between the anchors must absorb. Pipes are anchored midway between the expansion devices and at branch connections. The anchoring device is usually attached to a structurally sound portion of the concrete structure with sufficient area ground bearing.

Steam Traps

The purpose of steam traps is to confine the steam to the steam pipes or steam heating equipment in buildings while admitting condensate drainage to the condensate return line. Their capacity is measured in the amount of condensate in pounds per hour that will be discharged through the trap under controlled conditions of pressure differential and temperature drop. Underground pipes are pitched about one inch in fifty feet, and the condensate is drained through traps from all low points and at maximum intervals of 200 to 300 feet. There are an almost infinite number of types of traps, but they all employ one of two basic operational principles: temperature sensing and buoyancy.

Thermostatic traps are devices in which a temperature-sensing element discriminates between the steam and condensate temperatures, opening the valve to permit the flow of condensate but closing it to steam.

Float or buoyancy traps are devices in which the buoyancy of the condensate discriminates between steam and condensate.

Pressure-Reducing Valves

To assure adequate steam flows, distribution systems typically operate at higher pressures than are required for actual steam use in buildings. Distribution pressures normally range around 125 p.s.i while utilization pressures hover around 15 to 50 p.s.i. Pressure-reducing valves are installed on the branch lines to decrease the pressure to the level required. Gauges and safety valves should be installed on the low pressure side of the valves. Pressure-reducing valves should not be confused with pressure-regulating valves. Pressure-reducing valves cut the pressure to the point for which they are designed or set but do not prevent fluctuation caused by loads. Pressure-regulating valves, however, regulate the pressure to the amount that is required by the equipment used.

Steam Metering

The meters employed to measure the weight of steam used are of two types. The condensation meter is installed at the discharge end of the condensate return piping. It is a simple and low cost device but does not account for steam or condensate losses. Steam flow meters, which are of the displacement, orifice, or venturi type, are equipped with mechanical or electrical transmitting and recording devices. Properly calibrated steam meters are accurate but they are relatively costly.

3.4 CENTRAL HOT WATER SYSTEM

Although hot water is sometimes used as the heating medium in buildings, heat from a central plant is normally distributed by steam, which transfers its heat to water by means of heat exchangers in the buildings. Hot water distribution may be more economical over short distances on small campuses due to the lessened heat loss from the lower temperature medium. More effective corrosion-inhibiting water treatment is possible with water systems. However, difficulties are encountered on large systems with the high pressures and large piping required the unsuitability for many purposes of moderate temperature water at the extremities of the system, and the high installation and operating costs.

3.5 CENTRAL CHILLED WATER SYSTEM

Chapter 2, "Central Utility Plants," outlines the advantages of a central cooling plant with chilled water distribution. Consequently, no comprehensive treatment of the chilled water distribution system is included in this chapter. Piping considerations in a central chilled water system are similar to a steam distribution system with the following principal exceptions:

- External pipe corrosion poses a greater problem with chilled water piping due to moisture condensation on the conduits. To limit condensation a vapor barrier and thermal insulation are required.
- Pipe expansion and contraction are modest for a chilled water system.
- Corrosion control can be more effective in a chilled water system—through the addition of chemical inhibitors—than in a steam system.
- Installation and operating costs for the chilled water distribution system are high due both to the heavy piping and the extensive high-pressure pumping required.

CHAPTER 4

Building Mechanical and Electrical Systems

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4.1 INTRODUCTION

No function of the plant department is more critical than ensuring the safe and uninterrupted operation of each building's mechanical and electrical systems. While other factors bear on the total quality and suitability of a building, malfunctioning mechanical and electrical systems shut down the facility. In addition, no factor affects facilities costs more than the efficiency of these two systems.

This chapter is not intended as an engineering text for the design of mechanical and electrical systems. There are many technical publications for that purpose. The intent of this chapter is to present a comprehensive overview of mechanical and electrical systems in college and university buildings. The chapter introduces the reader to an organized classification of several methods and types of equipment. In nontechnical language the principal operational characteristics and relative costs of each system and component are discussed.

Although not meant as an engineering text, the material presented can be used to advantage as a practical reference text by all plant personnel who hold operation and maintenance responsibilities. It will foster a common understanding of all systems by both technical and nontechnical personnel and facilitate the further study of individual system components by technical staff.

4.2 BUILDING MECHANICAL SYSTEMS

The building mechanical systems discussed are heating, cooling, and air conditioning; plumbing; and fire protection. They comprise the operating systems that function within individual campus buildings.

The heating and cooling systems of a building are designed to maintain the desired temperature under all conditions. Air conditioning encompasses not only the maintenance of the desired temperature but also the control of humidity, odor, and air cleanliness. What follows is a discussion of heating methods and equipment, types of cooling, and, lastly, the various types of air conditioning systems. Since it is impossible to discuss the equipment and systems for heating, cooling, and air conditioning separately without some overlap, heating and cooling are included in the discussion of air conditioning systems.

Heating

There are three basic methods of supplying heating to a building: forced air systems, hydronic systems, and boilers.

Forced Air Systems In a forced air system, a fan moves air across a heat exchanger into ducts that convey it to the areas to be heated. The heat exchanger may be an oil- or gas-fired furnace, a hot water or steam coil, or an electric resistance heater.

With oil- or gas-fired furnaces, the furnace consists of two main components—a fan and a combustion chamber. Oil or gas is burned in the combustion chamber and the products of combustion pass through a heat exchanger. Air is heated as a fan moves it across the heat exchanger. A single thermostat may control both the combustion cycle and the fan, or a thermostat may control the combustion cycle while the fan is controlled by a separate heat sensor in the combustion chamber.

The gas-fired furnace has the lowest purchase price of any comparable heating system, while the oil-fired furnace costs somewhat more because of the storage feed mechanism equipment that is required. With either, maintaining a constant flow of medium temperature air is difficult due to the high temperature of combustion. Modulating control of the fuel supply alleviates the condition somewhat. These units are generally used in smaller buildings or for supplemental heating of areas with high heat loads.

A forced air system can employ hot water or steam coil heat exchangers to heat room supply air. The hot water or steam can be generated in a building boiler or central plant. An alternate method to heat water is in a converter using steam generated in a central plant. With hot water systems the water temperature can be reset as the heating load changes. A problem with steam coils is that steam condenses in the coil after the steam supply is shut off. The resulting release of the latent heat from vaporization can overheat the spaces served.

The purchase price of steam or hot water systems is higher than for oil- or gas-fired furnaces. However, with larger heating systems it is necessary to use this method because of its design flexibility and its ability to transmit the heat through greater distances.

Electric strip heaters can be used in a forced air system in place of a furnace or hot water or steam coils. To deliver heat in variable quantities, banks of heaters are staged to operate on demand. Alternatively, the temperature of individual heaters can be changed by modulating the electric current supplied.

Perhaps the greatest use of strip heaters in college and university buildings is for supplemental heating in air conditioning systems to closely control the temperature and relative humidity. (See terminal reheat system described later in this chapter). Electric heating is generally too costly to be used as a primary heating source except where the area to be heated is small or other methods are unavailable.

Hydronic Systems Hydronic heating systems circulate water or steam through unit heaters that transfer heat to the room through radiation or convection while the air in the room remains relatively motionless. There are two types: radiators/convectors and radiant heating systems.

Radiators and convectors are still used extensively in cold climates, especially in older buildings. The units are installed in inconspicuous places in the room, normally on the exterior perimeter. Most modern units have automatic temperature control. A room thermostat controls a valve that admits steam or hot water to the unit when heating is required. More sophisticated controls may include an outside controller that shuts down the steam or hot water supply to the building when heating is not required. Some contain features with nighttime or weekend setback. Steam pressures of 15 to 25 p.s.i. are typically used to minimize the problem of residual latent heat described for steam coils. When hot water is the heating medium, the unit is usually designed for water temperature reset by an outside controller that maintains minimum water temperature.

Radiators and convectors are relatively inexpensive and are effective methods of heating when forced ventilation is not required. They have several disadvantages, however. They are unsightly, noisy, heat rooms unevenly, and take up interior space. Their exposed hot surfaces are a hazard to occupants. As noted earlier, they do not have the capacity for ventilation.

The basic principle and major components of radiant heating systems are the same as for radiators and convectors. A hot water pump circulates the hot water through a series of pipe coils, normally spaced 12 to 18 inches apart, that are embedded in the wall, floor, or ceiling of a room. The water releases heat to the radiant panel, which in turn transfers the heat to the room by means of radiation and convection.

Radiant heating has the advantages that the heating elements are hidden from view and that hot or cold air drafts do not result. There are several disadvantages: ventilation is not an integral part of the unit, a long thermal lag develops between the time the controls act until the room is heated, purchase price is high, and repairing leaks is expensive.

Boilers Boilers are the third major method of supplying heat to a building. They are used to heat water or to generate steam for heating applications. Boilers are discussed in detail in Chapter 2, "Central Utility Plants."

Miscellaneous Heating Methods In addition to the three primary heating methods, some miscellaneous methods exist. One procedure is to use unit heaters. They are usually suspended from the roof structure or mounted on the floor. Air flow is unidirectional with high discharge velocities. Unit heaters are designed for use with oil, gas, electricity, hot water, and steam and are principally used to heat large open areas such as garages, shops, and storerooms. Typically they are controlled automatically with a thermostat that actuates the burner and fan simultaneously.

Heat pumps also fall into the miscellaneous category. They are an economical source of heat, but function primarily as an air conditioning system. A more detailed discussion of heat pumps is included in the section on air conditioning.

Cooling

It is only since World War II that cooling has been generally accepted as essential to the quality of higher education facilities. Few college and university buildings constructed before that time had any cooling equipment. Many of these buildings have not yet been equipped with cooling systems other than room air conditioners to serve selected areas. However, virtually all buildings constructed during the last thirty-five years have included mechanical cooling equipment. The exceptions are institutions in geographical areas where cooling is not needed—even during summer months.

There are three basic methods of providing cooling: evaporative cooling system, vapor compression system, and absorption system. The latter two are included in the broader term "mechanical refrigeration."

Evaporative Cooling System The evaporative cooling method proves effective only in areas with low humidity, so its use in university and college facilities is limited. The equipment is inexpensive and provides some temperature relief. Some drawbacks to this equipment exist:

- It discharges humid air (with 85+ percent relative humidity) into the space served.
- It requires large quantities of outside air that must be exhausted.
- It requires frequent maintenance.
- It cannot be used for spaces occupied by large numbers of people since it cannot remove the high latent heat that is generated.

There are two basic types of evaporative coolers: pad and rotary. Pad evaporative coolers use a blower to draw hot outside air through moist fiber pads. The air is then discharged into the room. A 10 to 15°F temperature drop is common in a dry climate. The unit is normally mounted on the roof or on a concrete slab. This is the least expensive type of evaporative cooler. A rotary evaporative cooler consists of a large corrosion-resistant screen wheel that turns in a trough of water. A fan blows across the top section of the wheel where the water evaporates and cools the air. Rotary coolers are used more often for larger applications than are pad types although rotary coolers are considerably more expensive.

Vapor Compression Mechanical System This system employs mechanical refrigeration. Any mechanical refrigeration system involves the circulation of a suitable working substance that:

- Is cold enough to absorb heat from the air of the space served or the air to be delivered to that space, and
- Gives up heat to relatively hot surroundings, generally to the exterior atmosphere.

The second process cannot be made to follow the first directly. There must be an interim step where energy is added to the working substance to increase its temperature to a value at least equal to the body or surroundings to which the heat is surrendered. In the compression system, a compressor is used to raise the temperature of the working substance to the desired amount.

The total compression refrigeration cycle works this way. The compressor acts on a low temperature, low pressure refrigerant gas, compressing it to a high temperature and pressure. The hot gas from the compressor is then discharged into a condenser that removes the heat of compression and condenses the gas to a liquid at constant pressure. The liquid is stored in a receiver.

At this point the liquid refrigerant is piped to an evaporator through an expansion valve where, under reduced pressure, the liquid vaporizes and absorbs heat from the air passing over the evaporator coils. The cool air is delivered to the rooms to be cooled. (This method of locating the evaporator coils directly in the airstream is known as direct expansion.)

The final step is one in which the low pressure gas from the evaporator is delivered once again to the suction side of the compressor to repeat the cycle.

The principal working equipment of a compression system is the compressor. There are two basic types.

One type is a reciprocating compressor. Energy is supplied by a prime mover, generally an electric motor, to drive the compressor crankshaft attached to pistons to compress the refrigerant gas. Reciprocating compressors range in capacity up to 125 tons. When greater capacities are required, they may be installed in banks.

With the second type, a centrifugal compressor, the gas enters an impellor driven by a prime mover and is compressed by centrifugal force. Centrifugal compressors range in size from 75 to 5,000 tons. They are not generally used in applications calling for capacities of less than 150 tons; at that size they cost more per ton and require more floor space than a comparable sized reciprocating compressor. Since building code requirements limit the amount of refrigerant that can be used in any one system, chillers are employed in large air conditioning projects. With chillers, the refrigeration system cools a second fluid, usually water, that is pumped to the cooling coils.

Centrifugal compressors are available in larger sizes than reciprocating kinds and, in the larger sizes, cost less per ton. They are reliable and require relatively little day-to-day upkeep. They are less noisy than reciprocating compressors and have better capacity variation. Their major disadvantages are that they occupy more floor space per ton and are more costly in sizes under approximately 150 tons. The centrifugal variety of compressors, running at 3,000 to 6,000 r.p.m., can be adapted to direct drive by steam turbines although electric motors are commonly used.

Absorption Mechanical Refrigeration System In an absorption refrigeration system, cooling is achieved when heat energy in the form of steam is supplied directly to evaporate and condense a refrigerant. Three pieces of equipment work in place of a compressor: an absorber, a solution pump, and a generator. Lithium bromide in the absorber attracts water vapor from the evaporator. As the water evaporates by being absorbed in the lithium bromide solution, it cools the water that remains in the evaporator. The chilled water is then piped to the cooling coils. As the water vapor reduces the concentration of lithium bromide, the solution must be reconstituted. This takes place in the generator where steam boils off the water vapor and discharges it to the condenser. The water from the condenser is returned to the evaporator. The reconstituted lithium bromide is returned to the absorber where the cycle begins again.

Compared with compression refrigeration, absorption machines have a higher purchase price and typically require more maintenance. They are not as energy efficient in terms of output per energy input. However, where electric power is generated on site and where exhaust steam from the turbines is available, absorption may prove to be the most economical refrigeration system.

Mechanical refrigeration, both vapor compression and absorption, involves the removal of heat from the space served and the transfer of it ultimately to the atmosphere. Technically, this involves transforming the hot gas from the compressor, or water vapor from the generator, to a liquid. The equipment used to accomplish this is a condenser. There are three types of condensers used in college and university buildings: air-cooled, evaporative, and water-cooled.

With the air-cooled device, a fan blows air across the coil to condense the hot gas. There are vertical and horizontal varieties, with the vertical suited to interior installation and the horizontal low silhouette type appropriate for roof mounting. Air-cooled condensers are energy inefficient and are normally limited to about 100 tons capacity each. A major problem is that they are least efficient on hot days when maximum capacity is needed. The principal advantage is that there is no requirement for water treatment as in evaporative and water-cooled condensers.

The evaporative condenser operates somewhat differently. The refrigerant is pumped through a coil over which water is sprayed. The water collects in a basin or sump from which it is pumped to repeat the cycle. A fan blows or draws air over the tubes counter to the flow of water. With the blow-through type, the fan is situated in the path of the dry entering air. With the draw-through kind, the fan is located in the path of the moist exiting air. As a consequence, the fan must be constructed of materials that resist rust and corrosion. Constant bleedoff of water is required to prevent a buildup of solids in the water and precipitation of scale on the coil. In climates where air conditioning must be intermittently operated in the spring and fall when freezing temperatures may occur, either the condenser must be drained or some other freezeup protection provided. Antifreeze protection may be accomplished by placing thermostatically controlled immersion heaters, steam coils, or hot water coils in the sump pan.

Evaporative condensers are sized to match reciprocating compressors and are generally limited to about 150 tons. Relatively inexpensive to install, their disadvantages are that water treatment is required, and rusting limits their life to about eight to twelve years.

Water-cooled condensers are located near, or as a part of, the compressor or absorption unit. There are several different types, each with distinctive characteristics and unique applications. The general operation is similar, however. Refrigerant is pumped through coils, mostly finned tubes, over which cooling water is circulated.

In the early days of air conditioning, the water was disposed of after flowing through the condenser. With the increased cost of water and the large quantities needed, current practice dictates reuse of water by means of a cooling tower. Using recirculated water means that water must be treated. Cooling towers operate similarly to evaporative condensers and are built to match the largest centrifugal or absorption machines. They require considerable maintenance, and their bleedoff and freeze protection requirements are similar to evaporative condensers.

Air Conditioning

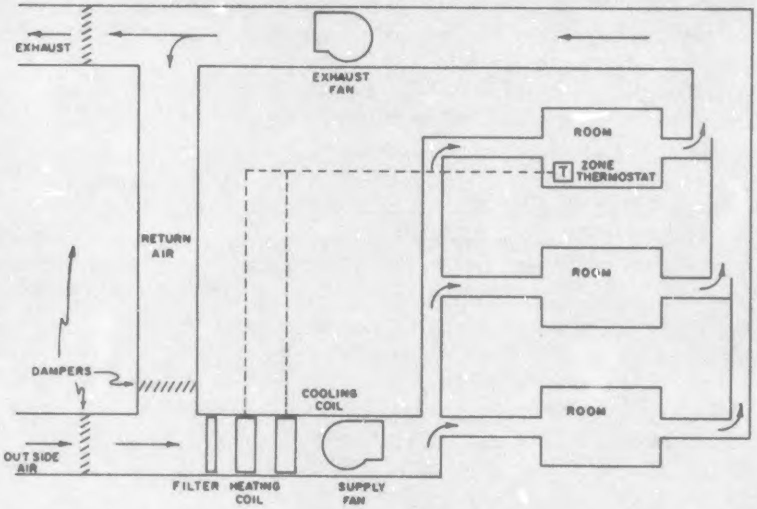
An air conditioning system comprises a number of features. It must include five essentials: heating, cooling, filtering, distribution of the conditioned air to the spaces served, and controls. Heating and cooling methods and equipment have been described above. Some of the equipment, such as radiators and convectors, are used as described earlier in the chapter. Others, such as evaporator coils of a compression refrigeration system, are an integral part of an air conditioning system.

The following discussion presents the major components of air conditioning systems used in college and university buildings: air distribution systems, filters, and control systems. In addition, humidification and dehumidification methods as well as piping systems for supplying steam or hot and chilled water to the air handling systems are explained.

Air Distribution Systems The manner in which the air is circulated varies depending on the type of system employed. There are numerous kinds of air handling systems that are in use.

A single zone system consists of heating and cooling coils, a fan for moving the air through the system, filters, and a means of mixing return air and outside air. (See Figure 4-1.) It has one control zone that controls the temperature of the conditioned air. Heating might be provided by a duct furnace or hot water coil and cooling by direct expansion or chilled water coil. A system thermostat activates either the heating or cooling coil depending upon what space requirements demand. This type of system is simple and comparatively low cost in both installation and maintenance. It is best suited for spaces with uniform heating and cooling loads such as lecture halls, auditoriums, and multiroom zones where all rooms have nearly uniform loads. It is particularly well suited for rooms located in a building that has stringent cleanliness and temperature control requirements. In these cases the components can be selected to meet the exact requirements. Since the same temperature air is delivered to all spaces served at constant rates, it is not suited to situations where internal loads vary widely within the area served.

A modification of the single zone system, the multizone system, separates the heating and cooling into a hot deck and a cold deck. (See Figure 4-2.) The discharges from these two decks are equipped with multiple sets of blending dampers—one set for each zone in the system. A dedicated duct runs to each zone. A zone thermostat operates the blending dampers to furnish the required temperature air to each zone. The amount of air distributed to each zone remains constant. An asset of the multizone system is its ability to meet nonuniform thermal loads of the various zones, permitting different temperatures to be maintained in each. A typical application would be a building with the long axis running north-south. Due to the sun load, the east side of the building would require less heating in winter and more cooling in summer during morning hours. In the afternoon, the west side would need less heating in winter and more cooling in summer. A multizone system could meet these changing requirements. The initial cost and space requirements of this


EXHAUST
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DAMPERS
COOLING COIL
ROOM
OUT SIDE AIR
FILTER
HEATING COIL
SUPPLY FAN

Figure 4-1

Single Zone Air Handling System

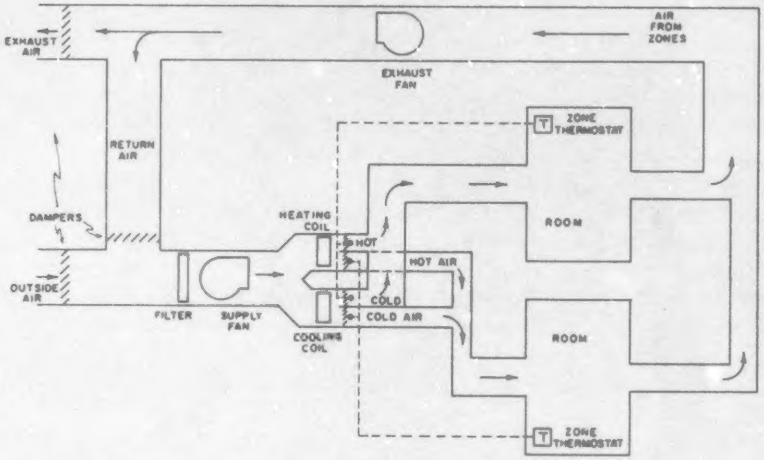

EXHAUST AIR
EXHAUST FAN
AIR FROM ZONES
T
ZONE THERMOSTAT
RETURN AIR
HEATING COIL
ROOM
DAMPERS
HOT
HOT AIR
OUTSIDE AIR
COLD
COLD AIR
FILTER
SUPPLY FAN
COOLING COIL
ROOM
T
ZONE THERMOSTAT

Figure 4-2

Multizone Air Handling System

system are higher than for the single zone system but maintenance costs are only moderately higher. Because the cooling coil is bypassed when cooling is not needed, the relative humidity can build up quickly on an exceptionally humid day. For this reason this kind of system is best suited for applications with small ventilation requirements.

The dual duct system is simply a multizone system with the air plenums extended and the mixing dampers located near the zones being served. (See Figure 4-3.) All the air is conditioned in a central apparatus and then distributed through two parallel ducts. One duct carries cold air and the other warm air, thus providing air sources for both heating and cooling at all times. In each conditioned space, mixing dampers controlled by a space thermostat blend the warm and cold air in proper proportions to satisfy the space requirement. The dual duct system has slightly higher initial and maintenance costs than the multizone. However, it gives complete flexibility to the building. That is, old zones can be changed or new ones added as long as the system's capacity is not exceeded. The dual duct system is especially suited to a building with a large number of rooms or areas requiring close temperature control, such as a research laboratory.

The terminal reheat system is basically a modification of the single zone system. (See Figure 4-4.) Air is supplied to all areas served at a temperature sufficiently cool to meet the requirements of the room or zone with the highest cooling requirement. A zone thermostat controls reheat coils for each zone. Consequently, the air to each zone is heated as necessary to maintain the required temperature. This system can maintain exceptionally accurate temperature control. It is best suited for use with a single zone system where some rooms vary widely in occupancy and lighting loads. It is slightly more expensive than the single zone system, and uses energy inefficiently.

The variable air volume (VAV) system is another variation of the single zone system. A single stream of either hot or cold air is supplied at high velocity to all spaces served. The air to each room or zone served enters a mixing box. A room or zone thermostat controls the temperature by adjusting dampers to regulate the volume of air entering the room. Dampers are preset for minimum ventilation needs. As zones are satisfied and the total air requirements are reduced, a static pressure regulator reduces the air flow by cutting down the speed of the supply and return air fans. The VAV system provides about the same degree of temperature control as the multizone and the dual duct. Its use is becoming more widespread because of its energy efficiency. The system capacity is continuously adjusted to load.

The induction system is well adapted to meeting the load characteristics of perimeter rooms in a building containing many rooms. It employs induction units that are installed in the periphery of the building, normally beneath windows. High-pressure, high-velocity, constant-volume air is supplied to the unit. The temperature of the air may be varied according to outside conditions. The stream of high-velocity primary air induces a larger volume

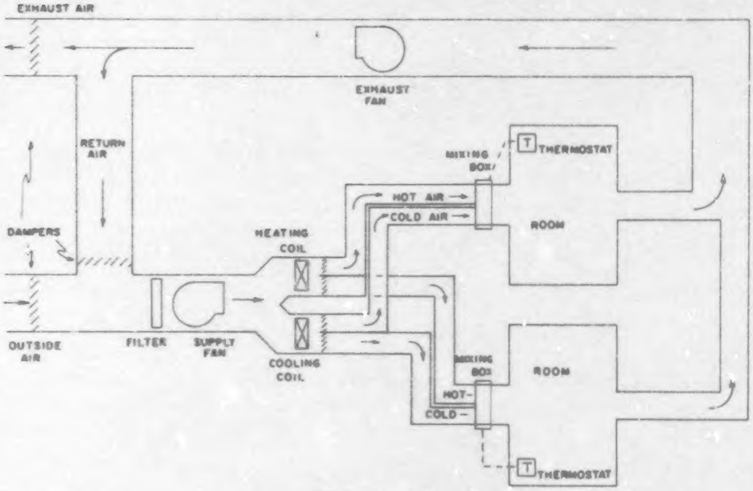
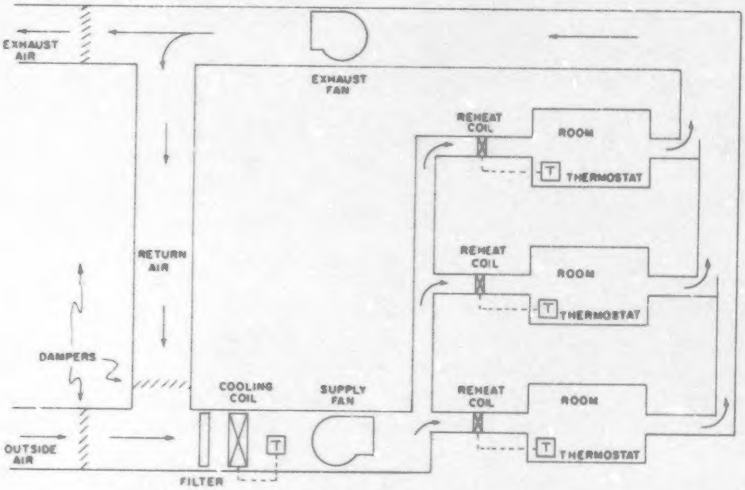

EXHAUST AIR
EXHAUST FAN
RETURN AIR
DAMPERS
MIXING BOX
T
THERMOSTAT
HOT AIR
COLD AIR
HEATING COIL
ROOM
OUTSIDE AIR
FILTER
SUPPLY FAN
COOLING COIL
MIXING BOX
ROOM
HOT
COLD
T
THERMOSTAT

Figure 4-3

Dual Duct Air Handling System


EXHAUST AIR
EXHAUST FAN
REHEAT COIL
ROOM
T
THERMOSTAT
RETURN AIR
REHEAT COIL
ROOM
T
THERMOSTAT
DAMPERS
COOLING COIL
SUPPLY FAN
REHEAT COIL
ROOM
OUTSIDE AIR
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FILTER
T
THERMOSTAT

Figure 4-4

Terminal Reheat Air Handling System

room secondary air through the heating and cooling coils of the induction units. The ratio of primary to secondary air is about 1 to 9, 10 percent primary and 90 percent secondary. A room thermostat controls the temperature of the heating and cooling coils or the damper regulating the flow of air into the room. The induction system is commonly used in high-rise buildings where there is a wide perimeter-to-core load ratio. It has the ability to provide desired conditions in each room of a building, and is especially suited to use in student residence halls. Maintenance and service costs are low.

The fan coil system is one in which hot and chilled water are circulated to fan coil units located in each room. The fan coil is a small air handling unit that is placed on the exterior wall or in ceiling space. A thermostat controls the supply of hot or chilled water to each unit; a manual switch controls the amount of air through the unit. The greatest advantage of this air distribution system is its adaptability to many building requirements. The system is widely used in dormitories, medical centers, and hospitals. It is one of the lowest first-cost type perimeter systems in use. The central station equipment that supplies the hot and chilled water is generally the same as any other system of comparable capability. Maintenance demands on the equipment within the controlled space are relatively low. One disadvantage of the fan coil system, however, is the lack of an inherent means of ventilation.

The unit ventilator has similarities to the fan coil unit but is usually larger and is designed to use outside air. Because of its intake capacity, it must have a means for exhausting the same volume of air as it draws in. Exhaust methods range from door louvers venting into hallways to duct work with motorized dampers. Due to the large number of individual units in this kind of system—each with direct access to outside air—the outside air control system is usually minimal. For this reason, the systems are generally not energy efficient. The applications for unit ventilators are the same as for fan coil systems. Unit ventilators, however, have the additional advantage of a ventilating capability.

The heat pump is a device that extracts low grade heat from a suitable source and upgrades the heat to a higher temperature by means of an external higher grade energy. It consists of a refrigeration compressor, an evaporator coil that collects heat, and a condenser coil that releases heat. Many times the roles of these coils are reversed by a series of automatic valves located in refrigerant lines. This unique feature enables the heat pump to become a source of heating as well as cooling, sometimes accomplishing both simultaneously. An example of this dual functioning is a setup where one coil is located in the airstream of a fan system that serves a building periphery and another is located in a similar system that serves the building core. The heat pump cools the core by extracting excess heat and delivers the heat to the perimeter areas. This elementary concept is effective only when there is a balance between interior cooling and exterior heating loads. Otherwise, a split condenser is required in which the heat not needed elsewhere in the building is dissipated by a cooling tower or evaporative condenser. If an auxiliary heat source such as a boiler or elecric heater is added for those times when exterior heat losses exceed interior gains, a year-round system is created. It is desirable for separate air handlers to be used for interior and exterior areas. Other sources of heating and cooling include outside air, well water, and exhaust air. Since the basic concept of the heat pump is one of redistributing heat, the device is best suited for buildings requiring simultaneous heating and cooling. Examples would be buildings that possess interior areas compared with their perimeter areas or facilities that house heat-generating equipment such as computers in the building's interior. Although capital investment for a heat pump system is high, the payback period in terms of energy savings can be quite short in suitable applications. Maintenance costs for the air-to-air heat pump are quite low. Systems that use water run considerably higher due to the need for pumps, regulators, heat exchangers, and water treatment.

Filters Filters are installed in an air conditioning system to clean the air that is supplied to the conditioned spaces. They are always located downstream from the point at which outside air and return air are mixed and ahead of the heating and cooling coils to keep the coils free of dirt. Three characteristics that distinguish the various kinds of filters are efficiency (the ability to remove particulate matter), resistance to air flow (measured by the static pressure drop across the filter), and durability (determined by the particulate holding capacity). When deciding which filter to use, it is wise to look at applications. Factors to be considered are the degree of cleanliness desired, disposal of dirt after removal, and amount and type of dust to be removed. These three factors affect initial cost, operating cost, and amount of maintenance that will be needed. The principal filter types used in college and university buildings are described.

Dry type filters are made of fiberglass, cellulose, wool, felt, cotton, and synthetic fabrics. Dry type filters are more efficient than the viscous impingement kind. In addition, the wide variety of media available makes it possible to achieve almost any degree of cleanliness that is desired. Dry filters have a high dust collection efficiency and tend to load quickly. When loaded, they block air flow. They are available with throwaway media and disposable frames, with throwaway media and permanent frames, or with an automatic roll feature. The automatic variety contains a motor that rolls the filter across the airstream. When the static pressure drop across the filter reaches a predetermined level, the motor automatically advances a clean section to the airstream.

Viscous impingement filters are flat, shallow assemblies. They work by forcing the air through the filter without slowing it down. The filter's medium is coated with a viscous substance, usually an oil or adhesive. Dust is thus removed by impingement on the viscous material. The filters are available in the frame or panel style, which can be cleaned or are disposable, and the moving curtain variety, which can include automatic cleaning and recoating. Viscous impingement filters are less efficient than the dry type, but their initial cost and upkeep are lower. The moving curtain type, like the automatic dry style, has the advantage of less maintenance and servicing.

Electronic and chemical filters have limited air conditioning applications for colleges and universities. Electronic filters use high-voltage electrically charged plates that are placed directly in the airstream to attract dust particles. Chemical filters consist of a belt of metal impingement filter material that is rotated across the airstream. Nozzles atop the filter spray a solution of glycerine, germicide, and odor-absorbing materials across the belt that work to clean the air. Both systems are expensive and are used in air conditioning only to meet special requirements.

Control Systems An air conditioning system is an integrated system of components, each of which plays an important role. The purpose of the control system is to operate the various components of the air conditioning system in consonance so as to achieve the most effective and efficient overall performance. Specifically, automatic controls are used to regulate the temperature and/or humidity in a space and to operate the system as economically as possible.

Control performance is typically evaluated in terms of:

- System stability, which is the absence of excessive periodic control oscillations.
- Control offset, or the minimum difference between the set point and the actual control point under stable conditions.
- System response, or the ability to correct rapidly for system disturbances.

A control system is composed of a number of parts: controllers, controlled devices, and auxiliary equipment. Controllers are thermostats, humidistats, and pressure sensors, while controlled devices come in the form of automatic valves, automatic dampers, and electric motors. Auxiliary equipment includes transformers that convert current to reduced voltages, as well as potentiometers, air compressors, and various kinds of relays.

Three fundamental types of controls are used in air conditioning systems. Two position (often called on-off) is one type. The second type employs floating action. Floating action controls are similar to on-off controls except that the controlled device can be stopped at any point in its stroke and reversed without completing the stroke. An example of this type of device is the slow-acting damper motor. When activated by the thermostat, the damper slowly starts opening or closing. When the space thermostat is satisfied, the damper stops and holds its position until the thermostat reactivates it to open or close.

A third type is the proportional or modulating action control. Here the controlled device moves to correspond to the change in the controller. An example is the thermostat that modulates the hot and cold air supply dampers of a dual duct system to maintain the set temperature.

Control systems can be classified according to their operational characteristics.

Electric systems feature electric controls that are in either line voltage (more than 30 volts) or low voltage (less than 30 volts). Line-voltage controls are used to operate relays, holding coils, etc., on pumps, fans, and compressor motors. Low-voltage controls can be used for the same purpose as well as for thermostat circuits. High-voltage controls are undesirable in controllers or controlled devices in occupied areas. Low-voltage controls are used in on-off, floating, and proportioning type controls. Line voltages are used only in on-off type controls.

In the pneumatic system air is supplied from an air compressor at 15 to 25 p.s.i. The air moves throughout the system in small copper or plastic tubing. Changes in the pressure from the controller cause a corresponding position change in the controlled device. In a small system, pneumatic controls are usually more costly than electric controls due to the cost of the air compressor. On larger systems, the pneumatic system is more economical.

Solid state electronic control systems have become increasingly popular in recent years. Since they operate on the principle of change in electron flow in a conductor due to temperature change, they provide accurate sensing. In addition, they have the capability to average the combined temperatures from several sensors. One exceptional feature of an electronic sensor located in an air duct is that it is not affected by stratification of the air flow since it averages the effect of the temperature along the entire length of the sensor. One potential problem with electronic controls may be maintenance. Since they are new devices, neither the plant personnel nor the contractor may be able to perform repairs.

Piping Systems Several kinds of piping systems are used for supplying the hot and chilled water to the heating and cooling coils of an air conditioning system, including fan coil and unit ventilator systems.

The two-pipe system consists of a single supply pipe and a sole return pipe so that only hot or chilled water can be supplied to the unit at any given time. Difficulties are encountered with this system where heating and cooling seasons are separated by long spring and fall seasons that call for intermittent heating and cooling or in cases where heating and cooling are required simultaneously in different parts of a building.

In the three-pipe system, one pipe is used for hot water, one for chilled water, and one for a common return. One drawback to this system is that low temperature water can sometimes be returned to the boiler and high temperature water returned to the chiller during the interim periods between the heating and cooling seasons. The results are low energy efficiency and possible damage to boilers or chillers. While slightly cheaper to install, the three-pipe system is a continual operation and maintenance problem.

Four-pipe systems completely separate the heating and cooling media, thus avoiding the problems of the one- and two-pipe systems. Heating and cooling are available simultaneously so that separate air handling systems can provide heating and cooling at the same time. The four-pipe system is more costly to install, but provides more satisfactory service during the transition periods between the heating and cooling seasons. It is well suited to buildings such as laboratories that have varying heat loads in different parts of the structure.

Heat Recovery from Building Exhaust Prior to the escalation of fuel costs, various means of heat recovery were viable but not used extensively in the United States. Increases in energy costs have sparked greater interest in this technology and spawned the development of new technologies. When properly sized, a heat recovery unit can substantially cut heating and cooling operating costs, lower electrical demand charges by reducing the amount of air that is handled and water that is pumped, and can reduce the sizes of coils, condensers, and refrigeration compressors.

The heat recovery unit transfers heat between the building's air exhaust and the air intake. In winter it transfers heat from the exhaust air to preheat the fresh air supply. In summer, it transfers heat from the fresh air supply to the lower temperature exhaust air, thus cooling the fresh air supply.

There are two basic types of air-to-air heat recovery devices: package units transfer heat between two adjacent ducts and split systems transfer heat between supply and exhaust ducts that are widely separated.

Package units move heat between adjacent ducts. Heat or energy wheels, heat pipes, and plate-type counter-flow devices are the three basic types of package units.

The heat or energy wheel is a wheel with a heat exchange surface medium. The medium is available in a variety of materials including metal, foam, felt, fiberboard, and wire mesh. The operating principle of the wheel is to heat the medium in the exhaust airstream and then rotate the medium to the supply airstream, thus warming the incoming air. The opposite occurs in winter. The heat exchange surface medium is typically belt driven by an electric motor and operates at a low speed in the range of 20 r.p.m. One disadvantage of the system is cross contamination between the exhaust and fresh air supply. With prefilters and proper purging, this problem can be largely overcome. In calculating the economics of this system, it is necessary to include the cost of operating the electric motor that drives the wheel, the increased fan horsepower needed to overcome the pressure drop through the wheel, and the cost of any duct alteration necessary to place the supply and return ducts adjacent to one another.

The heat pipe, a second form of package unit, is a passive energy recovery device. It requires no external energy for operation. The mechanism consists of a closed tube containing a capillary wick structure and a small amount of working fluid. The fluid, which is selected for each application, evaporates when it is heated at one end of the tube. The vapor flows along the tube to the opposite end, where it gives up its latent heat and condenses to a liquid state, returning to restart the cycle by a combination of gravity and capillary action in the mesh. The tubes vary in length from 100 millimeters to 3 meters. No cross contamination results since the sealed partition separates the two streams that flow in opposite directions. There are no moving parts to wear out, so the manufacturer normally offers lengthy guarantees. The heat pipe is somewhat less efficient than the heat wheel. As with the heat wheel, the supply and exhaust ducts must be adjacent.

The plate type counter-flow heat exchanger, the third kind of package unit, allows the supply and exhaust air to flow through narrow passages located adjacent to each other so that every other passage carries exhaust air and, alternately, supply air. The energy is transferred by simple conduction through the walls of the passages. The device is constructed of metal, plastic, or fibrous material. Because there are no moving parts, little maintenance is required. Furthermore, cross contamination is not a problem. Its efficiencies are comparable to the heat wheel.

In everyday situations it may prove impossible to route exhaust and supply air in adjacent ducts, either by design or through retrofitting, in which case a package unit cannot be used. In such cases, split systems may fit the need. The fundamental split system is the run-around coil or loop system. The heat exchanger in the exhaust duct heats or cools a heat transfer liquid, which is usually ethylene glycol or water. The fluid is pumped to the supply air where the inlet air is conditioned. The system is versatile in its application. As for efficiency, it is comparable to the heat pipe but not quite as efficient as the heat wheel or plate type counter-flow heat exchanger. Cross-contamination does not present a problem. When determining the economics of the system, it is imperative to consider the amount of power needed to operate the circulating pump as well as the increased fan horsepower.

Humidification and Dehumidification With institutional facilities it may at times be necessary to raise or lower the humidity of the supply air to maintain selected humidity conditions in the air conditioned space. There are three major ways to control humidity.

One way is to use an on-off humidifier that employs water spray or steam. A humidistat in the conditioned space senses a need for more humidity and turns on the humidifier that is positioned in the air handler. When the humidity in the space reaches the set-point of the humidistat, the humidifier is turned off.

A different type of humidifier uses a combination of refrigeration and heating. With such a system, the humidity of the supply air furnished to the space can be closely controlled. The supply air is first cooled, then saturated by the humidifier, and later heated to the desired temperature. The temperature to which it is cooled is determined by the ultimate relative humidity and temperature desired. It is the temperature of saturated air (100 percent relative humidity) which, when heated to the temperature at which it is to be delivered to the space, will be at the desired relative humidity. This system performs either humidification or dehumidification.

Chemical dehumidifiers use a chemical absorbant that can usually be continuously regenerated. One type uses a wheel containing silica gel that revolves first through the conditioned air, where it absorbs moisture, and then through the regenerative airstream, which dries the gel. The space humidistat controls the heating coil in the regenerative airstream. Another type uses a water-absorbing liquid chemical solution that is sprayed over a cooling coil in the conditioned airstream, thus absorbing moisture from the air. Part of the solution is continuously pumped to a regenerator where it is sprayed over a heating coil and surrenders moisture. Controlling the humidity of the conditioned air is accomplished by controlling the temperature of the solution.

Plumbing

Until the early 1960s, plumbing was largely handled by technicians who were guided by the Uniform Plumbing Code. The last twenty years have seen a rapid advance of technologies and ever more stringent codes and standards regarding the welfare and safety of personnel. This new focus on welfare and safety has led to new codes and standards that include plumbing system solutions to fire safety. In addition, plumbing manufacturers have moved to design new equipment, such as automatic sprinkler systems and water fountains that are accessible to the handicapped, with these new considerations in mind.

Uniform Plumbing Code provisions still apply except where more stringent codes and standards have been established by other government agencies. An example would be Section 504 of the handicapped accessibility regulations prescribed in 1976 by the U.S. Department of Health, Education and Welfare (HEW).

College and university buildings can be characterized as having highly diverse functions. They accommodate large numbers of people and have unique requirements for plumbing facilities. The information presented here is intended to bring attention to the various types of plumbing equipment that are installed in college and university buildings and to point out major design and installation considerations. Since building plumbing systems are not integrated technical systems as, for example, air conditioning systems are, it is not necessary to present a detailed description of the various kinds of equipment. That information can be found in other resources. Rather, the important design and installation considerations of plumbing systems are highlighted.

Number of Fixtures The Uniform Plumbing Code establishes the minimum plumbing facilities needed for the various types of buildings, such as classroom buildings, office buildings, theaters or auditoriums, and residence halls. It should be noted that in some cases the standards have been superseded by more stringent regulations set by other government agencies.

Toilet Design A number of considerations pertaining to plumbing for institutional facilities are presented to help facilities managers plan for better service and ease of maintenance.

- Walls and floors of tile set in epoxy cement can minimize maintenance and facilitate cleaning.
- Public toilet areas, especially in buildings with high occupancy, should be designed to facilitate traffic flow. For men's toilets, a separate entrance and exit that permits routing to the urinals, the lavatories, and then exit should be designed. A secondary use pattern should be devised that leads to the water closets, lavatories, and then exit. This provides for expeditious use and minimized maintenance. Women's restroom areas are designed in the same manner, with a space reserved for makeup tables with seats.
- Water closets are available in several models. Elongated bowls with openfront seats are generally preferable. Flush valves provide more satisfactory service with minimum maintenance. There are four basic types: siphon jet, reverse trap, washdown, and blowout. The blowout types feature economical use of water and are generally used where good flushing action is required but noise is not a factor. The siphon jet has the quietest flushing action and is commonly used where noise is a consideration, such as in libraries and hospitals. Wall-mounted closets cost approximately 25 percent more than floor-mounted models, but greatly facilitate floor cleaning. Colored fixtures cost about 25 percent more than white but are becoming increasingly popular.
- The wall-mounted urinal is normally preferable to the floor-mounted type although the floor-mounted version offers greater floor protection.
- Lavatories with a splashback are preferable because they are most easily cleaned. To reduce water consumption, metered

faucets should be installed. Pop-up drains are a maintenance problem and, consequently, are not used in public buildings.

Drinking Fountains The Uniform Plumbing Code, or other code that applies, specifies the numbers of drinking fountains by type of occupancy. When installing the fixtures in hallways, care should be taken to ensure compliance with building fire codes regarding exit obstructions.

Service Sinks Service sinks in janitors' closets should include hose thread faucets and steel rim guards to prevent the porcelain from chipping. Floor sinks with wall-mounted faucets are the most convenient kind of fixture to use and are generally less costly.

Chemical Waste Considerations An important consideration for the plumbing systems installed in laboratories is how the drains and other components can accommodate chemical waste. The waste can be handled in drains made of high-silicon iron, glass, or polypropylene. Polypropylene is the least expensive type drain but bends easily and must be carefully supported. It is not, however, resistant to certain chemicals. Glass and high-silicon iron can withstand high temperatures, are resistant to all chemicals except hydrofluoric acid, but are relatively expensive.

Chemical Eye Washes and Showers Applicable safety standards prescribe the amount needed and the minimum travel distance permissible to chemical showers and eye washes for chemical laboratories.

Distilled Water One special requirement for all laboratory buildings is that they have distilled water. In many cases it is most economical to install a central distillation unit and run distribution piping to all laboratories in the building. Care should be taken to provide for an adequate distilling capability and adequate storage facilities that will be needed during peak class periods.

Water Heaters Hot water heaters service domestic hot water usage in the building, hot water for laboratories, and other special needs. Where there is a building or central boiler, the hot water is produced in a heat exchanger in the building. Otherwise, the hot water heaters used are typically the electric or gas types. Where higher temperature water is needed for special purposes such as dishwashers or cage washers, it is preferable to provide booster heaters to meet the special requirements and maintain the domestic hot water at the lower temperature. Care should be taken to ensure suitable capacity of the building water heating system, especially where alterations have increased the demands. For example, washing research animal cages requires large quantities of hot water and the building system can quickly be overburdened by adding such a requirement.

Handicapped Facilities The accessibility requirements for the handicapped established by HEW include provisions for plumbing facilities. Standards are spelled out for accessibility to restrooms, depth of water closet stalls, wheelchair turning space, height of water closets, and special hardware such as handrails or grab bars. Specifications are noted for accessibility to lavatories and their controls. Additionally, the height, depth, and controls for water fountains are addressed.[1]

Fire Protection Systems

The fire protection requirements for buildings are established by the Uniform Building Code, the National Fire Protection Association (NFPA), and by state and local codes. In most cases, the most stringent regulation applies. Apart from code considerations, the second most important factor that bears on what fire protection facilities are installed in a building is an institution's insurance. Since premiums may be reduced by preventive action, building or renovating facilities with this in mind makes good sense. For example, adding certain devices such as sprinkler systems may, through reduced insurance premiums, pay for themselves within a relatively short time. Insurance carriers can provide information on the savings to be gained through specific measures.

There are three basic fire protection systems for buildings: wet standpipe, dry standpipe, and automatic sprinklers.

Wet Standpipes Wet standpipes contain water under minimum pressure and feed fire hoses located in fire hose cabinets. The water pressure is generally in the range of 30 p.s.i. Codes prescribe that all parts of a building must be located within a maximum distance from a fire hose of maximum length. If the water supply system will not provide the minimum pressure needed, particularly on upper floors of a building, a booster pump or gravity tank must be installed. Follow codes for details on certain construction considerations, markings for fire hose cabinets, and how frequently to replace hoses.

Dry Standpipes Dry standpipes are used as a backup system in the event that the building's primary water system fails. Hose gate connections to the dry standpipe are usually located in a fire-rated stairwell and should assure convenient access to fire fighters. When a dry standpipe is needed, a pumper truck is connected to it to furnish the water supply.

Automatic Sprinklers Automatic sprinkler systems are prescribed for certain spaces. In general, spaces where they are required are:

- Areas where the functional use involves a higher than average fire hazard.
- Areas that are intermittently occupied and contain flammable materials.

- Areas with a limited number of exits relative to the number of occupants.
- Areas in which a fire might block an exit route
- Exit routes without minimum fire-rated walls.

Sprinkler head spacing is determined by the building type, occupancy, and hazard rating. A deluge system, used for extra hazardous areas, operates with all valves open. A heat sensor actuates the valve that discharges water into the system.

Special Systems In addition to the standard fire protection systems, special fire protection systems are available that may be used in college and university buildings. They are:

- Carbon dioxide system that reduces the oxygen content of the air below the point required to support combustion. This system is used in areas where highly flammable solvents, such as paints, are stored.
- Foam systems, which employ an organic foaming agent. These systems work by smothering fires and are used to combat oil fires.
- Water fog or mist systems, in which the extinguishing agent of water is broken up into a fine mist. They are used to fight hot fires and in situations where the electric conductivity of a water stream may be a problem. An advantage of this system is that it reduces water damage.

4.3 BUILDING ELECTRICAL SYSTEMS

The counterpart to the building mechanical system is the electrical system and its components. This section presents a basic description of that system and its operating characteristics.

The information centers on the electrical systems within a building rather than the external system that carries power to a building. In cases where the electrical supply comes through a campus distribution system, transformers are normally located in isolated vaults in each building. However, the transformers are a part of the distribution system, not the building system. The building system starts with the supply of utilization voltages, typically from the low side of the transformer. Many mechanical devices inside a building use electric equipment such as motors, temperature control circuits, and electric heaters. Since these devices involve more than electrical work, they will not be discussed.

Basic Components

The basic components of a building electrical system are switches, power outlets, conductors and wiring, relays, and lighting.

Switches Switches are used to make or interrupt an electric circuit. Rated in voltages and amperes, care must be taken to be sure that the circuit load does not exceed their rating. The basic types of switches, some of which are overlapping, are described below.

The standard single-pole wall switch is used primarily for lighting but is also suitable for low-voltage, low-current devices such as small fans and laboratory equipment. These break only the live circuit.

The double-pole switch is another variety. In order for power equipment to be fully isolated, it is often desirable to break both the live and neutral circuit, calling for two contacts to work side by side. This kind of switch is used to switch electric heaters, larger fans, and similar type equipment of about five amperes or more.

The time switch has a timing mechanism to actuate a circuit on a preset time schedule. These devices are used principally for lighting control.

The photoelectric switch is a mechanism in which a photoelectric cell makes a circuit when illumination falls below a certain level. It breaks the circuit when the illumination rises. Used primarily for switching exterior lighting, it has the advantage of taking into account weather conditions. An added advantage is that it does not require continuous resetting throughout the year as the daylight hours vary.

A load-break switch is one that is designed to interrupt load-level circuits but not the larger fault circuits. When two current contacts first part, a voltage appears between the contacts. Because they are initially infinitesimally close together, electric arcing may occur—producing intense light and heat. The heat can damage the contacts and other parts of the switching device. At low voltages this is not a problem, but it is a problem at higher voltages such as those used by electric motors of building air conditioning systems. Load-break switches are designed to effectively break such circuits.

Disconnect switches are designed to disconnect the power apparatus when there is essentially no current. They are used as a means to open a circuit for servicing.

Circuit breakers are switches designed to interrupt faulty circuits. (See Distribution System and System Protection.)

Power Outlets Socket outlets are female sockets connected to the power wiring in the building. They are used for office machines such as typewriters and calculators and for low-voltage portable laboratory equipment. Outlets rated up to 15 amperes are generally two-plug. Those rated for 15 amperes or more have a third plug for the ground wire. It is advisable in new construction and alteration projects to add surplus outlets in order to facilitate the addition of office electrical equipment and to permit the rearrangement of offices as occupancy increases or declines. This can be done more economically during construction rather than subsequent to occupancy.

In all instructional spaces, outlets should be provided for clocks. Special outlets may be required to accommodate the clock connector, which has a special low-ampere fuse to protect the clock mechanism.

Laboratories commonly need special services such as low-voltage and direct-current outlets. Research projects often create demands for outlets to be installed along the entire length of a laboratory bench to grant flexibility in locating components. Low voltage can be supplied from a transformer in the laboratory, which can either provide a fixed secondary circuit or an adjustable type that offers a choice of voltages. Laboratory units are made for this purpose. Because the units often contain rectifiers, they provide a source of low-voltage direct current as well. Strip outlets that accommodate male plugs can meet the requirement for location flexibility. One additional requirement for laboratories is that of stable voltage characteristics so that sensitive equipment can be operated. Using a "regulator transformer" is usually the most effective way to meet this requirement.

Conductors and Wiring Electricity is transmitted in metal conductors that must be isolated and protected against mechanical damage. When the metal conductor—or wire—is insulated to make it suitable for carrying electricity, it becomes a cable. This provides a convenient distinction between a bare and an insulated wire, but in practice wire and cable are used interchangeably.

Copper is the most common material used in conductors although aluminum is also popular. Aluminum has more disadvantages than copper but is cheaper. The conductors are usually produced by twisting several small strands together to make a conductor of the required capacity. A wire produced this way has greater flexibility.

Insulation is used to restrict the flow of current within the conductor. When the current exceeds the breakdown strength for the insulation, undesirable conduction paths are created and the system is disabled. The most common insulating materials are thermoplastics, vulcanized rubber, silicone rubber, and glass and asbestos fiber. Thermoplastics are perhaps the most widely used, although they have the disadvantage of becoming brittle at near-freezing temperatures and soft at high temperatures. Vulcanized rubber often becomes brittle with age and is not as resistant to chemicals as thermoplastics. Silicone rubber resists moisture and withstands temperatures up to about 300°F. It is often used in hospital and research equipment that must be sterilized. Glass fiber and asbestos are highly heat resistant and not normally used in college and university buildings.

Radio and television system cable must carry a weak signal at high frequencies. To avoid loss of the signal, the cable must have a low impedance at the frequency being used. It must also be constructed so that it does not pick up unwanted high-frequency signals. To meet these demands, a single insulated conductor is used with a metal cover over the insulation to screen the conductor from unwanted signals. The metal is in turn protected by a nonconducting cover. Thus, the insulation, metal sheath, and cover are circular, on the same axis as the conductor. This has become known as coaxial cable.

To protect the cable and to guard occupants and equipment from inadvertant grounding due to breaks in the insulation, electric wiring is normally installed in conduit. There are three basic types of conduit.

Steel conduit is specially annealed so that it can be readily bent. Heavy-gauge steel conduit is normally joined together by screwed fittings while light-gauge conduit employs grip-type fasteners. The connection to motors and other mechanical equipment is usually made with flexible conduit, an overlapping corrugated structure in which the corrugations open out when the conduit bends.

Polyvinyl chloride plastic conduit is increasingly being used in place of heavy gauge steel. It is cheaper and more easily installed than steel yet is noncorrosive and unreactive to most chemicals. Its disadvantages are that it becomes brittle at near-freezing temperatures and soft at about 150°F, and has a high coefficient of expansion. It is an insulating material (i.e., thermoplastic), so it cannot be used for the ground circuit.

The wire mold type is a two-piece rectangular steel conduit that is designed for surface installation on walls where appearance is important. It is normally two piece. A channel is attached to the wall and the wire placed in the channel. An outer cover then snaps on the channel. Its cost is generally twice that of the standard steel conduit.

Relays A key component of any electric system is the relay. A relay is a device that, upon a signal, performs switching actions. For example, a large number of electric lights on a single circuit may draw too much current to be switched by an on-off device such as a time or photoelectric switch. In such cases, the switch is used to activate a relay, which then opens or closes the light circuit. Its name derives from the fact that it "relays" the signal. Relays are important in system protection, which is discussed later.

Lighting Effective lighting is of utmost importance in accomplishing the teaching and research missions of colleges and universities. This importance, together with energy conservation considerations in recent years, has resulted in intensive study of the types and layouts of electric lighting. Chapter 5, "Energy Management and Conservation," discusses the efficiencies and expected life hours of the various lamps commonly used in colleges and universities. Once a lighting system has been chosen, circuits, wiring, and protection must be designed for the systems. The electrical requirements depend, to a considerable extent, on the kinds of lamps used.

Incandescent lamps consist of a thin filament of tungsten inside a glass bulb filled with an inert gas under low pressure. They are designed so that the filament glows when current passes through it. The color of the light varies with the temperature, becoming more white as the temperature rises. The current taken by incandescent lamps is purely resistive. Incandescent lamps can be dimmed for special effects by simply inserting a resistance in series with them. They are particularly effective where true color renditions are important.

Fluorescent lighting, either recessed or surface mounted, has become the principal light source in college and university buildings. This is primarily due to their efficiency. Although specific efficiencies are linked to the size and type of lamp, fluorescent lamps in general require one-fourth to one-third the electrical energy of incandescent lamps for the same light output. Fluorescent lamps consist basically of a long glass tube that contains a mixture of mercury vapor and argon gas that is coated on the inside with a fluorescent powder. When an electric voltage is applied, electrons flow through the vapor from an electrode at one end (cathode) to an electrode at the other end (anode). This current passing through the vapor at low pressure causes the vapor to emit radiation at wavelengths that depend upon vapor pressure. The fluorescent coating absorbs the radiation at one wavelength and emits radiation over a band of wavelengths. This secondary radiation falls in the visible spectrum. Its color depends upon the material used for the coating. The voltage required to start the electrode discharge is much higher than that required to maintain the discharge, so the voltage must be reduced once the discharge starts. This is accomplished by a series ballast. Fluorescent lamps have a lower surface brightness than incandescent lamps. They cannot be dimmed by inserting resistance to reduce the current. Dimming requires the use of a low-voltage transformer to supply the electrodes with a separate heating current. As a result, the electrodes are permanently heated while the current is varied to cause dimming. The transformer provides a permanent heating current that is independent of the current passing through the tube, and the latter can then be varied by a resistor. The dimming process with fluorescent lamps is much more expensive than with incandescent lamps.

Mercury discharge lamps operate on the same principle as fluorescent lamps. The differences are that they contain no fluorescent coating and the light emitted is the primary radiation from the discharge itself. The discharge must, therefore, provide radiation in the visible spectrum. Mercury vapor lamps give off a white light and are used where high intensity or good color rendition is important. They are used for outdoor lighting where aesthetics are important, such as in central plazas and malls.

Sodium discharge lamps have a similar action to mercury discharge lamps, but are filled with sodium rather than mercury. They work at low pressure and their luminance is low. The sodium gives off a characteristic yellow color. The low-pressure sodium is the most efficient means yet known of converting electrical energy to light energy, but because of the peculiar color their use is generally limited to street lights and similar applications.

The higher pressure sodium lamp casts more sunny yellow light and has come into extensive use in outdoor campus lighting.

Distribution System and System Protection

A cable brings the electric service into a single point within the building and from that initial supply point electricity must be distributed to various points of use. It would not be economical to supply each point of use from the entry point in the building—the length and/or size of conductors would be prohibitively costly. Therefore, a building system typically includes submains from the central supply to subdistribution points, often located on each floor, in addition to several circuits from each of the secondary distribution points that supply each point of use. The cable for each circuit is chosen to carry the maximum simultaneous current taken by all components of the circuit. At the same time, appropriate protection is provided against overload of the circuit rating. This network of cable, switching, and protection equipment comprises the building electrical distribution system.

Distribution Panels Distribution panels are sectionalized assemblies of switches and circuit breakers that distribute the building electrical supply to various parts of the building. Standard boards normally have connections for 4, 6, 8, 12, 16, 18, or 24 circuits, each accompanied by a fuse or disconnect-type circuit breaker. However, most larger switchboards are designed and built to specifications for the building. It is not necessary to use all circuit connections available. Good design practice allows for at least 25 percent system growth potential when installing a distribution panel.

Panel Boards Often referred to as circuit panels, panel boards are located at subdistribution points. They are normally located on each floor of a building and are fed by submains from the main switchboard. The panel boards in turn supply electricity and overcurrent protection to individual circuits.

The number and location of distribution panels, including panel boards, depend upon the building plan. Building space and access for servicing must be considered. However, the dominant considerations are to balance the lengths of the submains and the lighting and load circuits to find the most economical way of keeping voltage drop within the building system to a minimum. In cases of large buildings or where extensions are added to existing buildings, it is sometimes desirable to add on one or more subsidiary distribution panels.

The electrical distribution system in buildings commonly includes secondary circuits of two capacities: a 277/480-volt three-phase and a 120/208-volt single-phase. The 277/480-volt three-phase normally serves the buildings' heating, cooling, and ventilating equipment plus elevators. However, it may sometimes also serve large exterior lighting systems. This service is normally run from the main distribution panel to a separate panel board in the mechanical room.

It is common practice to meter electric usage in individual buildings. Where a campus distribution system exists, the metering of individual buildings is not normally required by the utility company since the supply to the distribution system is metered. Building meters are required where there is no campus distribution system, and buildings are supplied individually. However, the metering of individual buildings, and even of high-load circuits within a building, can greatly assist an institution in conserving and managing energy.

A large part of any system design is to ensure that accidents will not happen. Or that if they do happen, effects will be limited. It is a general principle of protection that a faulty circuit should be cut off from the supply and isolated as soon as possible. The three dangers to be guarded against are fire, shock to people, and damage to equipment. These accidents are generally caused by three kinds of fault: overload, phase-to-phase short-circuit, and phase-to-ground fault.

Overload When an excessive mechanical load is imposed on an electric motor, it continues to run but draws a higher current than normal. As a result, the circuit supplying the motor carries a higher current than that for which it is designed. A fault in the internal wiring of electric motors or other electrical equipment can also cause an overload. Although the overload is not as high as with a short circuit, it can cause excessive heating. Perhaps the greatest danger with such circuit overloading is the generation of heat that burns away the insulation and results in a phase-to-phase short or grounding. The overload can also damage a motor or other electrical equipment. However, system overload protection is meant for the building circuits. Equipment should include its own protection.

Phase-to-Phase Short Circuit If the line and neutral conductors become connected, the current that flows is limited only by the resistance of the cables and the impedance of the contact between the cables. In such cases, the current is high and could burn the insulation. The result could be a fire or phase-to-ground fault.

Phase-to-Ground Fault A fault to ground occurs when a conductor becomes connected to a ground source. The result is similar to a phase-to-phase short circuit except that the current potential is much higher and damage can be more severe and rapid.

A number of protective devices serve as safeguards against accidents. These circuit protective devices are fuses and circuit breakers.

Fuses contain a wire that melts from the heat of an overload current. They are low cost and can be sized for a wide range of applications. Disadvantages are that their calibration can be affected by ambient temperatures and they are nonadjustable. Fuses are seldom used in new installations.

Circuit breakers contain an overcurrent sensing component that trips the breaker. Their response time depends upon the magnitude of the overload, though they trip instantaneously in the case of a complete short circuit. Circuit breakers cost more initially than fuses, but they are permanent. That is, they are adjustable and can be reset after tripping.

Special Equipment and Requirements

Buildings require certain special equipment related to the facility's electrical systems. For instance, facilities must have emergency lighting in case of power outages. In other cases, buildings require protection from lightning strikes.

Building codes require emergency lighting that comes on if the electric supply to the building lighting system fails. The loss of the electric service can occur either because of a problem within a building system or a problem in the distribution system. Therefore, emergency lighting must be able to function independent of the building system. The emergency lighting is intended to provide adequate light for marking exits and for people to find their way out of the building. Where uninterrupted electric service is necessary, such as in hospitals or certain research buildings, structures are regularly equipped with a standby generator that is automatically started by an electric outage. Generators, however, are too expensive for anything but high-priority requirements. Emergency lighting is normally battery powered and works on low-voltage direct current. A charger permanently connected to the building system keeps the battery fully charged. The lights are wired from the battery through a relay, the contacts of which are held open as long as the building system is energized. When a electric outage occurs, the relay closes and the emergency lights come on.

Special building electrical equipment such as fire alarms, intercoms, telephones, and public address systems are not standardized and the manufacturer must supply design and installation information.

Luminaire heat recovery units are special building electrical devices plant managers need to be aware of. A typical fluorescent lamp emits about 62 percent of its energy in the form of recoverable heat. Luminaire heat recovery units work to recycle the heat. The way they operate is that air is drawn over the light fixture through slots to the ceiling plenum and is then either routed to the return air duct or delivered to an induction box and returned to the room through the air diffusion system. During the cooling season, the air can be discharged to the atmosphere, thus reducing the cooling load. Such recovery systems increase lamp and ballast life.

Some buildings may have special requirements such as protection from lightning. Lightning can occur in two forms: either a discharge from a charged cloud to nearby tall objects or a discharge that occurs suddenly when a positive potential difference between a cloud and the earth is established suddenly. This latter type is often induced by the first, and may miss tall objects and strike the ground. Protection can be supplied by a lightning conductor. A lightning conductor works by attracting a strike that might otherwise hit some portion of the building. For practical design, it is normally assumed that satisfactory protection can be given to a zone consisting of a cone with its apex at the top of the conductor and the base of radius equal to the height of the conductor above the ground.

Whether or not a building needs protection is a matter of judgment. Factors to be considered include number of occupants, type of construction, contents (for example, explosives, power stations, or gas works) height of structure, degree of isolation, topography of the area in which it is located, and lightning prevalence.

Codes, Standards, and Sound Engineering Practice

The equipment and methods described above are intended to explain the ins and outs of building electrical systems. No other utility system requires greater knowledge of, and adherence to, technical standards and methods to ensure the safety of occupants and reliability of the system's operation. Electric service is normally not connected to a new or renovated building until a licensed technician certifies that the building electric system complies with applicable codes and standards. This procedure is normally not required in colleges and universities that operate their own electric distribution systems since they are governed only by such regulations and policies as the institution may adopt and enforce. Adherence to appropriate codes, standards, and good engineering practices is generally the responsibility of the director of physical plant.

Building electrical systems must be designed to provide current flow under controlled conditions of voltage, load, and demand. The characteristics of electric circuits such as resistance, reactance, impedance, voltage, current, power factor, available fault currents, and demand loads are evaluated by the engineer and reconciled to design objectives. Special provision must be made for hazardous, wet, contaminating, or corrosive environments as well as for temperature extremes. The electric circuits and equipment must be installed in accord with accepted regulations and practices. This includes the National Electric Code, applicable provisions of the National Fire Protection Association (NFPA), and local codes, regardless of their legal status in any given case.

END NOTE

1. See ANSI A117.1 for further information.

CHAPTER 5

Energy Management and Conservation

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5.1 BACKGROUND

Energy management received little attention at most colleges and universities prior to 1973. Since then, energy management and conservation have been subjects of exhaustive investigation and analysis in both the public and private sectors. Effective energy management has become a major requirement of all physical plant departments.

Emphasis on energy management dates from the OPEC oil embargo of 1973, which interrupted the supply of oil from the Middle East and led to immediate major shortages and price increases. But while the embargo triggered the emphasis, the problem results from several factors.

A primary factor was the vast expansion in facilities of higher education during the past 25 years. The expansion alone required a severalfold increase in energy usage.

At the same time, energy inefficiencies developed at the new facilities. While engineers have always been sensitive to the wastage of resources, they apply their technical knowledge to developing solutions based on criteria established by clients. During the campus expansion period, they devoted efforts to constructing the maximum expanse of facilities at the lowest cost to meet the ever-pressing requirement of rapidly growing enrollments. Energy and operating costs were low and therefore not major considerations.

Recent major increases in energy costs have had direct bearing as well. In most areas of the United States fuels and energy unit costs have increased severalfold over the past ten years. The price increases date largely from the end of the facilities expansion period.

The problem stemmed also from limited funding. Inflation and added requirements have raised government costs to levels traditional revenue sources are unable to meet. While energy costs have been increasing at a faster rate than inflation, appropriations have often not even kept pace with inflation. Businesses can absorb cost increases in product prices, but colleges and universities have a limited cost pass-through capability. They must meet increased costs with budgets that are restricted by general fund availability. Contributing to the funding problem is the new transition period that higher education has entered, in which enrollments are expected to drop or—at best—level off.

In summary, the expansion in facilities of limited energy efficiency and increases in unit costs of energy have added vast new funding requirements to physical plant budgets. The percentage of plant budgets allocated to providing essential utilities has more than doubled in most cases and even quadrupled in some. Simultaneously, public and private funding agencies are experiencing difficulties in meeting all justifiable funding requirements. While soaring energy costs present a major problem, they also offer a unique opportunity to meet needed cost reductions. The high cost of energy affords the opportunity for substantial cost reductions through improved efficiency of operation. Unlike most cost reductions, reduced energy consumption does not have a long-term detrimental impact on the accomplishment of the institution's central mission, nor is it a mortgage on the future.

5.2 SCOPE

As a result of the extensive study and research of energy during the past ten years, new materials and methods have been introduced at a rapid rate. There is no reason to expect this to change. Costs related to energy conversion, transmission, and consumption change regularly. Conservation cannot be a list of do's and don'ts since few hard and fast rules apply to all situations. Rather, conservation must be a dynamic process, with measures based on an individual diagnostic approach and careful engineering analysis of each building and system. Therefore, this chapter presents basic principles and considerations in formulating an energy management program. Data on materials and processes, which are ever-changing, can be obtained from current publications.

5.3 PLANT RESPONSIBILITIES

The physical plant department has responsibility for the operation and maintenance of facilities in support of the institution's academic and research missions as well as the budgeting and fund administration involved. In fulfilling this responsibility there must be reciprocal support from the faculty, staff, and students. Perhaps in no other cost-reduction program is success so dependent upon the cooperative efforts of all personnel. While the director of the plant must normally provide the institutional leadership for the conservation program, there must be a firm commitment to the program by the top administrators of the college or university.

The responsibilities that all employees of the physical plant department have in formulating and managing an energy conservation program must be recognized. The assignment of responsibility for each of the measures and components of the program must be compatible with the organizational structure. Employee suggestions and participation are to be encouraged. The commitment of plant employees to the program provides greater effectiveness in accomplishing individual duties and enables each member of the department to assist in leadership of the program in their daily contacts with other members of the college or university community.

5.4 BASIC PRINCIPLES OF ENERGY MANAGEMENT

Energy is the product of power and time. By reducing the level of power or the time it is applied, energy consumption will be reduced.

There are three fundamental methods of conserving energy:

- Using energy only where and when needed to provide minimum acceptable conditions.
- Minimizing heat loss and heat gain.
- Ensuring optimum efficiency in the operation of energy converting, transmitting, and consuming systems and equipment.

To achieve conservation the energy management program must address two areas: the technical area and the end-use limitations area. In addressing the technical area, life cycle costs should be the criteria for selecting equipment. The maintenance and operations program must keep it in efficient working condition.

Looking at end-use limitations, energy-consuming equipment should be used only at the level, in the location, and for the time required. The demands placed on an energy system by the occupants are normally the greatest determinant of the amount of energy consumed.

5.5 BASIC DEFINITIONS AND CONCEPTS

In order to discuss energy management with clarity, it is useful to set forth some basic definitions and concepts.

Load factor describes the percentage of time a connected load is used. Even though a system or item of equipment is inefficient, if its use-time is limited, limited savings potential can be realized. For example, replacing a 75-watt incandescent lamp in an administrative storeroom used three hours a week with a ninety dollar fluorescent lamp that is 300 percent more efficient would not be cost effective.

The thermal weight of a building determines the degree to which heat energy requirements are determined by outside temperature, and therefore the cost effectiveness of insulation, changed thermostat settings, etc. The dividing line between thermally light and thermally heavy buildings is generally considered to be about four watts/sq. ft. and about sixty hours/week of use. For thermally light buildings, heating requirements are determined by outside temperatures. For thermally heavy buildings, the internal load is the major concern and outside temperatures have much less effect.

A primary concept in energy management is that most building energy consumption occurs during moderate weather conditions. A plot of energy use by time of year or by outside temperature reveals that most of the annual energy consumption takes place during moderate weather conditions rather than at extremes of temperature. This is because the temperature falls in the moderate range such a high percentage of the time. Our main concern must be with how efficiently buildings and their systems operate during moderate temperatures, or a majority of the time.

Another fundamental concept is that of incremental benefit versus incremental cost. For most conservation measures, there is a diminishing return on an institution's investment. The determination must be made as to what gives an optimum return for each increment of change. A two- to five-year payback is a fairly common guide (calculated with 1983 cost index).

Related to load factor is the building occupancy rate, which is the average percent of the assignable space of the building that is in use at any time. College and university buildings have low occupancy rates. The utilization rate of classrooms and other teaching facilities normally runs from 60 percent to 65 percent due to the concentration of classes in prime-time hours. Faculty members are often absent from their offices for teaching, attending conferences, etc. Class break periods during holidays and between semesters, and reduced loads in summer sessions further reduce occupancy rates. The average occupancy rate of most college and university buildings is less than 50 percent.

5.6 ENERGY USES AND SOURCES

There are five basic utilities essential to the operation of university buildings: electric power, heating and cooling, water supply, liquid sewage disposal, and solid waste disposal. All are dependent upon the two basic energy forms: electric power and heat. Most of the energy is used for heating and cooling, illumination, and operation of conveyances and other equipment. Although not actually a use, heat loss and heat gain must be considered in energy management.

The sources of energy at institutions can be a mix. As a matter of fact, colleges and universities vary in the ratios of "purchased to generated" utilities to meet their electric and thermal requirements, ranging from 100 percent purchased to 100 percent generated. Many factors determine the most economical arrangement in each situation, but the principal ones are the rates and rate structure for purchased electric power, availability and costs of fuels, and the capacity and condition of existing plants. Major alterations to heating plants and electric generating facilities involve high capital investments, and are usually best accomplished in conjunction with expansions or replacements of major components. But the regularly changing situation pertaining to the availability and cost of energy makes it necessary to continuously reevaluate existing systems, processes, and fuels for greater economies.

An energy management issue that should be investigated on campuses is the correlation of electric and thermal requirements. The integration of electric power generation with thermal systems offers the potential for substantial energy savings. It is difficult for small onsite electric generating plants to compete with the high efficiencies of large generating facilities of utilities companies. But generation of a portion of the electric power needed may be more economical if exhaust heat can be used to meet thermal requirements. Where electric power is both generated and purchased, load limiting procedures are necessary to keep within the established demand limit of the purchased power. Procedures should include phased startup of intermittently operated equipment, proper sizing of motors and other powered equipment, load shedding, and other measures to limit the simultaneous operation of electric equipment.

Heat recovery is an energy extending option. Onsite incineration of solid wastes can reduce the volume of waste and generate heat that can be fed into the electric-thermal system. Such plants regularly use either bulk burning or refuse-derived fuels. There is promising research in partial pyrolysis to produce a fuel gas that can be burned in conventional boilers. It is also frequently feasible to recover heat from relatively small operations in buildings such as computer or research reactor operations. The heat from these can often better be used for supplementary purposes such as heating boiler feed water or domestic water rather than feeding into the primary thermal system. (See "Heat Recovery From Solid Waste," Chapter 2, "Central Utility Plants.")

Extensive research on new energy systems and sources progresses. Although not yet economical, active solar energy systems are perhaps the most advanced of those applicable to colleges and universities. But colleges and universities, individually and collectively through APPA, must keep abreast of changes and assist new developments that may make additional energy sources economical.

5.7 UTILITY DISTRIBUTION SYSTEMS

Depending upon the kind of utility, distribution can be accomplished in various ways. The means for efficiently distributing electricity, steam, and low-temperature hot water follow.

Electric Distribution Systems

There are many factors bearing on the efficiency of a high-voltage electric distribution system as well as the electric system within each building. Some of the more critical elements are—power factor, system maintenance, and transformer management.

Although low power factors are normally not a major problem in college and university buildings, periodic checks should be made. A typical cause of low power factor is lightly loaded motors that draw excessive amounts of reactive power. Since the capacitors needed for power factor improvement are inexpensive, there is normally a short payback on their purchase and installation.

The maintenance of a system plays an important part in its effective operation. A good program of electrical system maintenance can help prevent excessive energy losses, can lengthen equipment life, and prevent hazardous conditions associated with poorly maintained equipment. Even though adequate when designed and installed, a building electrical system may not be able to carry the required current due to increased loads and changes in equipment layout. Additions and shifts in equipment may have affected working voltages, in turn influencing motor operation, lighting efficiencies, and conductor loading. Excessive line losses can result in low voltage conditions to motors. Undersized wire, loose connections, and bad contacts cause power losses, overheating, and arcing. Power leaks to ground can result in substantial losses. (See "Distribution System and System Protection," Chapter 4, "Building Mechanical and Electrical Systems.")

Transformer management, too, figures into electrical system distribution efficiencies. Significant energy savings can be realized through proper maintenance and management of transformer operation. The following practices should be considered:

- Shade exterior transformers from the sun to prevent heat buildup.
- Clean and ventilate transformer banks to keep them as cool as possible.
- Deenergize transformers whenever possible.

Steam Distribution Systems

Energy conservation considerations require that special emphasis be placed on certain facets of the maintenance and operation of steam distribution systems. For example, care should be taken to prevent excessive heat loss by repairing leaks, faulty pipe insulation, and malfunctioning steam traps, valves, and other distribution components.

In addition, the system should be operated at the lowest possible temperature and pressure. An adequate pressure must be maintained to meet load requirements, but energy input is required to raise pressure and the higher pressure can increase losses.

Low Temperature Hot Water Distribution Systems

A low-temperature hot water distribution system transmits heat more efficiently than a steam system. Steam and condensate leakages are obviated and losses from thermal conduction are greatly reduced. The absence of pressure-reducing valves, steam traps, and similar equipment in a water system promotes lower maintenance costs. The internal corrosion that commonly occurs in a steam condensate system can be controlled in a water system by the addition of chemical inhibitors not available to a steam system. A careful analysis to determine the most economical system should be made whenever appreciable replacements, renovations, or additions to an existing steam system are necessary.

5.8 ILLUMINATION

The lighting systems of many college and university buildings were designed with initial cost economies as the primary consideration and prior to the development of high-efficiency lamps. Many designs provided for general high-level illumination without input on how space was to be used and without benefit of recent research in the field. Therefore, there exists on campuses the potential for significant energy conservation through lighting modifications and management.

There are three basic factors that affect economy in the use of electric power in lighting. They are:

- Efficiency of the fixture and lamp.
- Level of illumination.
- Economy in lighting use, most directly affected by the length of time the illumination is used.

Lamp Efficiency

Figure 5-1 lists the various types of lamps most commonly used in college and university facilities, with corresponding mean light output in lumens per watt and the rated life in hours. The data are applicable only to the most commonly used lamps within each category and are for general comparison only.

There are many factors to be considered in selecting the type lamp for each requirement, including intensity or lighting level, aesthetics, protection from weather, and vandalism. Nowhere is load factor more important than in evaluating lamp replacements.

The level of illumination is affected by the cleanliness of the lamp and fixture reflector, and by the color and cleanliness of walls, floors, and ceilings. Light colored walls and ceilings give good reflectances. Walls, ceilings, floors, lamps, and reflectors must be kept clean for maximum efficiency.

Lamp efficiency deteriorates during the life of a lamp. Light output, consequently, should be checked regularly with light meters to ensure that minimum lighting levels are maintained. This is especially important where lighting levels have been reduced to the minimum.

Levels of Interior Illumination

During the decades of low-cost energy, lighting standards were established at optimum levels and minimum consideration was given to the operating cost. In the past eight to ten years, however, governmental and professional engineering organizations have reviewed these standards with a view toward striking a practical balance between the level of illumination and energy consumption. This has resulted in lower recommended levels for most functions. Figure 5-2 presents the Federal Energy Administration's recommended lighting levels.

Economy in Lighting Use

Economies can be achieved in a variety of ways. For example, switching may be installed, resulting in greater economy through task lighting. An instance where this practice would be recommended is in an office containing both a desk and a conference table. There the lighting for each may be placed on separate switches since only one or the other will normally be in use at any given time.

Decorative lighting should be reduced to the minimum considered essential to the desired function of the institution, such as for a limited time each night or for special occasions.

Outdoor lighting should be limited by area, intensity, and time to that required for safety and security.

The greatest savings can perhaps be realized through the exercise of economy by all personnel in the hour-by-hour use of lighting. For instance, the following steps can lead to savings:

- Turn off lights when leaving offices, classrooms, and laboratories.
- Use minimum lights required for the task being performed when separate switching is provided.
- Make maximum use of natural lighting in arranging offices and other work spaces.
- Train custodians working nights to turn on lights only in the immediate area in which they are working.

Figure 5-1

General Lighting Lamp/Ballast Characteristics[a]

Lamp Type	Wattage Range	Initial Lumens per Watt Including Ballast Losses[b]	Average Rated Life (Hours)
Low Pressure Sodium	18-180	62-150	12,000-18,000
High Pressure Sodium	35-1,000	51-130	7,500-24,000 +
Metal Halide	175-1,500	69-115	7,500-20,000
Mercury Vapor			
Standard	40-1,000	24-60	12,000-24,000 +
Self-ballasted	160-1,250	14-25	12,000-20,000
Fluorescent			
Standard	20-215	63-95	9,000-20,000 +
Self-ballasted	8-44	22-50	7,500-18,000
Incandescent	60-1,500	13-24	750-3,500

NOTES:

a. Data are based on the more commonly used lamps and are provided for comparison purposes only. Actual results to be derived depend on factors unique to the specific products and installations involved. Consult manufacturers for guidance.

b. Lumens (of light output) per watt (of power input) is a common measure of lamp efficiency (efficacy). Initial lumens per watt data are based upon the light output of lamps when new. The light output of most lamps declines with use. The efficiency of all lamps declines with use. The actual efficiency to be derived from a lamp depends on factors unique to an installation. The actual efficiency of a lighting system depends on far more than the efficiency of lamps or lamp/ballasts alone. More than lighting efficiency must be considered.

SOURCE: National Lighting Bureau and Energy Task Force, *Lighting Energy Management for Colleges and Universities* (Washington, D.C., 1982), p. 14.

Figure 5-2

Recommended Interior Lighting Levels

Lighting Function	Foot-Candles*
Prolonged office work that is difficult visually	75 (on task only)
Normal office work, libraries, and classrooms	50-75 (on task only)
Hallways and corridors	5-15 (average)

*Levels are averages and must be adjusted to meet special requirements in individual cases.

5.9 HEATING AND COOLING

Thermal conditioning constitutes the largest single block of energy used in college and university buildings in the course of a year. Nowhere in the entire energy realm is there greater diversity of equipment. Systems and equipment range from antiquated radiators to central systems that automatically switch between heating and cooling. Most systems installed during the expansion period of the 1950s and 1960s were designed with comfort and initial cost as the principal criteria, rather than operating costs. Many were oversized and inefficient under normal load conditions. In perhaps no other area is there greater potential for savings than through controls and modifications.

Types of Systems

The following are the most prevalent types of heating and cooling systems in college and university buildings:

- Radiators and convectors.
- Fan coil system.
- Unit ventilators.
- Single-zone system.
- Variable air volume (VAV) system.
- Multizone system.
- Dual-duct system.
- Terminal reheat system.
- Induction system.

Basic Conservation Measures

Careful engineering analysis is required in the adjustment and alteration of heating and cooling equipment for energy efficiency. Few measures yield similar paybacks or are even cost-effective under all circumstances. The measures described are intended only to invite attention to those that have proven most successful to date and therefore are recommended for consideration in establishing an energy management program. Measures for each system are discussed in "Conservation Measures by Type of System." What follows, however, are basic considerations common to two or more systems:

- Use lowest possible static duct pressure. It is often cost effective to increase the duct size in order to reduce pressure.
- The cost of moving a ton of cooling through an air duct is about ten times that of moving a ton of cooling through chilled water pipes.

- Enthalpy sensors and controls are normally profitable on existing buildings where there is at least a 20,000 CFM ventilation rate, where motors and dampers exist to exercise control, and where the climate is conducive to operating conditions.
- Caution should be exercised in the use of economizer cyles, which work on the principle of flushing heat out of a building. Economizers are normally not profitable on systems that use mixing to meet requirements in situations where heat recovery systems are in place or where there is high relative humidity.
- Chillers connected in series give more cooling capacity for the same power input and are generally more efficient for short hours of operation. For long hours, chillers connected in parallel may be best.
- Check the relative size of compressor-evaporator-chiller systems. Each comes in standard sizes, but system mix may cut efficiency of the system.
- Consider part-load performance in the purchase of equipment. Efficiency drops off rapidly under low-load conditions.
- In general, 2 percent to 4 percent of energy utilization is saved for each degree the chilled water temperature is raised.
- Draw-through forced draft cooling towers use only 30 percent to 50 percent of the energy of a blow-through type. However, blow-through units are lower in initial cost and fit into smaller spaces.
- Hot gas bypass on a refrigeration system is a total waste of energy but may be necessary for low-load conditions; the unit is kept running but energy is totally lost. Consider multiple smaller units.
- The condition of condenser tubes greatly affects efficiency. The frequency of cleaning, whether mechanical or chemical, depends upon the quality of water and the water treatment.
- There is a difference in efficiencies of air- and water-cooled condensers. The comparative efficiencies of air- and water-cooled condensers are substantially affected by relative humidity.
- Double-bundle condensers are exceptionally efficient. They work on the principle of storage of heat for use when needed for short periods.
- In general, 2 percent to 5 percent of energy utilization is saved for each degree that interior temperatures are raised during cooling or are lowered during heating seasons.
- Where a high ventilation rate is required, heat exchangers, which use exhaust air to precondition outside air intake, may be cost effective.

- Heat pumps are not as efficient in cooling as conventional air conditioning systems. Neither are they as efficient in heating as conventional heating systems. Their advantage is in simultaneous heating and cooling. This is usually applicable to a thermally heavy building.
- Meeting special heating and cooling requirements for small portions of buildings can be costly. Computer rooms, experiments requiring special environmental conditions, and similar special requirements may necessitate the operation of a building heating and cooling system when the remainder of the building can be shut down. Consideration should be given to meeting limited requirements by concentrating them in as few areas as possible and installing supplemental heating and cooling units.
- Economies may be realized during low-load conditions by interconnecting the cooling systems of two or more buildings. Cooling equipment operates at maximum efficiency at or near maximum load. In mild weather, virtually all building cooling systems may operate at low load. It is often possible to interconnect the chilled water piping of two or more buildings to operate off the cooling plant of one building. Several buildings may be connected into one chilled water loop. The chiller equipment of several buildings cycles on as required to meet the total load.
- Duty-cycling of fans of heating and air conditioning systems is predicated on excess capacity. Reducing fan speed may be a better solution.
- For thermally heavy buildings, cooling degree days have little effect on air conditioning costs.

Conservation Measures by Type of System

Depending on the type of heating and cooling system, various conservation measures should be undertaken.

Radiators and Convectors Radiators and convectors are generally low energy users due to the lack of ventilation. Problems are their slow response to varying load conditions and the propensity of occupants to leave them operating at maximum capacity while opening and closing windows to regulate interior temperatures.

Appropriate conservation measures include:

- Installing valves with automatic controls for shutting off steam or hot water supply to individual units.
- Installing a valve in the steam supply line to the building, actuated by a combination exterior-interior temperature sensing device. Night setback can be included with the control.

- Keeping heat transfer surfaces clean and free of obstructions.

Fan Coil System The fan coil is an efficient system, but includes no ventilation and no inherent means of night setback.

To save energy in this system:

- Reduce air flow and balance water flow to minimum satisfactory levels.
- Shut off fans and let coils act as convectors when heating and cooling loads are minimal.
- Avoid simultaneous heating and cooling.

Unit Ventilators A unit ventilator operates similar to a fan coil unit. It has, however, a means of supplying outside air and normally has an integral damper system. It is one of the most efficient systems.

To conserve energy, take the following steps:

- Reduce air flow and balance water flow to minimum satisfactory levels.
- Shut off fans and let coils act as convectors when heating and cooling loads are minimal.
- Avoid simultaneous heating and cooling.
- Limit ventilation to that required, including reductions when space is unoccupied.

Single-Zone System A single-zone system is one which provides heating and cooling to one zone controlled by a zone thermostat.

With a single-zone system, take these conservation measures:

- Avoid simultaneous heating and cooling except as required for humidity control.
- Consider converting single-zone single-duct system to variable volume.
- Modify piping to use cooling coil for both heating and cooling.

Variable Air Volume (VAV) System A variable air volume system provides heated or cooled air at constant temperature to all zones served. VAV boxes in each zone or space adjust the quantity of air reaching the zone, based on space load requirements.

To conserve energy with a VAV system:

- Limit the volume of air handled to the minimum.
- Install reset controls that regulate the hot and cold deck temperatures according to demand and outside conditions.

- Raise air supply temperature such that the VAV box that serves the space with maximum load is fully open.

Multizone System A multizone system heats and cools several zones, each with different load requirements, from a single central unit. A thermostat in each zone controls dampers that mix hot and cold air to meet the changing load requirements. A multizone system has poor energy efficiency.

To save energy with a multizone system:

- Achieve smallest possible differential between hot and cold decks.
- Use automatic outside controlled reset of coil temperature and pump operation.

Dual-Duct System In a dual-duct system, each space is served by two ducts—one carrying hot air, the other cold air. The central unit provides heated and cooled air at constant temperatures. The ducts feed into a mixing box for each space. A thermostat controls the mix of hot and cold air to achieve the temperature required.

Ways to conserve energy in this system are:

- Raise cold deck temperature and lower hot deck temperature as much as possible. Reset according to outside conditions.
- Limit air flow to the maximum extent possible.
- When there are no cooling loads, close off the cold duct and shut down the cooling system; reset the hot deck according to heating loads and operate as a single-duct system. When no heating loads are present, follow the same procedure for heating ducts and hot deck.
- Consider converting to variable air volume.

Terminal Reheat In a terminal reheat operation, a central heating/cooling unit provides air at a given temperature to all zones served. Secondary terminal heaters then reheat the air to meet load requirements in each space. This system is inefficient and should be used only when a high level of control is needed.

With a terminal reheat system, take these conservation steps:

- Reduce supply air quantity as much as possible.
- Raise supply air temperature during the summer months to the highest degree that will maintain satisfactory room conditions.
- Adjust damper controls in winter to raise supply air temperature to the maximum that will meet requirements without mechanical cooling.
- Adjust reheat temperature according to outside conditions.

Induction System An induction system consists of an air handling unit that supplies heated or cooled primary air at high pressure to induction units located on the outside walls of each space served. The high-pressure primary air is discharged within the unit through nozzles inducing room air through a cooling or heating coil in the unit. The mixture is then discharged to the room at a temperature that depends upon the cooling and heating load of the space.

Users of induction systems can take the following conservation measures:

- Set primary air volume to original design values when adjusting and balancing.
- Inspect nozzles to determine if they have become enlarged. If enlarged, adjust nozzle pressure to the appropriate setting.
- Set induction heating and cooling schedules to minimum acceptable levels.
- Reschedule the temperature of the heating and cooling water according to load. Avoid simultaneous heating and cooling.
- Shut down the primary air fans and raise the hot water temperature for operation during unoccupied hours [illegible] the heating season. The induction units will then operate as gravity convectors.

5.10 HEAT LOSS AND HEAT GAIN

The purpose of heating and cooling is to compensate for heat loss and heat gain in a building. The heating and cooling loads can consequently be cut by reducing the heat gain in summer and heat loss in winter. The primary factors influencing heat loss and gain are infiltration, transmission, solar impingement, and internal loads.

Infiltration

This energy loss occurs when unwanted outside air infiltrates a building through openings in the building envelope. Since all air introduced into the building must be heated or cooled, and sometimes humidified or dehumidified, this adds a load to the heating and cooling systems. Most infiltration occurs around doors, windows, and building joints and through doors that are opened when people move in and out of the building. To combat infiltration, the following conservation measures can be taken:

- Replace worn or broken weatherstripping around operable windows and doors.
- Caulk around door and window frames.
- Keep windows closed and adjust heating and cooling systems to maintain desired interior temperature.

- Construct a second set of entrance doors to create an entrance vestibule.

Transmission

Transmission refers to the transfer of heat through the building envelope. Transmission losses can be cut by adding insulation or modifying the window glazing characteristics such as replacing windows with double-glazed units. Installing tight-fitting storm windows should be considered when the combined infiltration/transmission savings justify the measure. Caution should be exercised to assure that calculations of savings in reducing transmission losses are not based on extreme temperature conditions that exist for short periods.

Solar Impingement

The sun's effect, solar impingement, is of primary concern in two areas: solar impact on roofs and solar properties of windows. When dealing with roofs it is important to remember that two factors—the results of solar impact and the roof's thermal quality—determine insulating value. The total equivalent temperature differential is determined by both factors. The solar impact can be reduced by painting the roof a light color. It is, however, normally more profitable to concentrate on the thermal quality.

The solar properties of windows are determined by several factors:

- Solar properties of the glass such as its color and reflective qualities.
- Architectural design for exterior shading.
- Interior shading through use of shades, blinds, or drapes.

5.11 ENERGY AUDITS

Energy consumption in buildings does not lend itself to easy quantitative analysis. It is possible to measure energy performance in terms of annual fuel costs or average consumption per square foot, but this is sketchy information when compared with the numerous factors that must be analyzed to understand and control energy usage. Variations in design limitations, type of building maintenance, building use, operation of the energy-using systems, weather data, and other factors make it difficult to establish realistic norms for each building or determine how much improvement is feasible. Yet to formulate and administer an effective energy management program requires determining where, and in what amounts, energy is used and where and how reductions can be made. To do this requires a knowledge and understanding of certain key elements:

- Operating characteristics of all energy-using systems under all operating conditions.
- Space operating conditions required by functional use.
- Energy consumption of each energy-using system by functional area.
- Time and magnitude of load peaks.

From the foregoing, measures can be identified for operating and maintaining acceptable space conditions with minimum energy expenditure. The following describes the steps that can be taken to establish an effective energy management program.

Obtain historical data on energy use by individual building. An analysis of these data will help establish priorities for further studies.

Conduct a walk-through audit. A walk-through audit is a physical examination of a building's major energy sources, equipment, and uses. Along with the observation, design documents should be reviewed for information on capabilities, sizes, and design intent. This kind of audit provides a general, broad understanding of the energy systems, functional uses, and operating and maintenance conditions of the building. From it managers formulate opinions regarding the energy improvement potential and identify obvious conservation measures. Measures in this category fall primarily in the management, operating, and maintenance realm and might involve reorganization of working hours, reductions in lighting levels, calibration of thermostats, and adjustment of thermostat settings.

Perform a detailed energy audit. The walk-through audit and review of historical data give direction to further energy evaluations that normally take the form of a detailed energy audit. Briefly described, this involves calculating the energy load by system type and use conditions, determining actual usage, and determining methods to reduce usage. Since most measures subsequent to those identified in the walk-through audit require capital expenditures, the cost of each measure and the expected payback must be calculated. The evaluation of each measure must include a recognition and evaluation of the problems that are likely to occur in its implementation.

Maintain an ongoing energy audit. The ongoing audit measures the effectiveness of actions taken, tracks down irregularities, and permits changes and improvements.

Consider the use of computer simulation. In larger buildings or those with complex HVAC systems, computer simulation or modeling may be valuable. Simulation of modifications cannot begin until the program simulates existing performance and is of limited value until all pertinent data are available. Perhaps the greatest use of simulation is in determining the likely impact of combinations of modifications for a fine-tuned program.

Central control systems, central chiller plants, and other equipment at college and university facilities have an impact on energy management. They and the efficiencies involved are discussed elsewhere in this book.

CHAPTER 6

Computerized Energy Management Systems

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6.1 INTRODUCTION

Computerized energy management systems (CEMS) for buildings have been used in the physical plant environment since the early 1970s. When the systems were first introduced and sold to colleges and universities, they were hailed as the magic computers that would solve all the building control problems on the campuses. Unfortunately, as many plant administrators can attest, the installation of many of these CEMS were not well thought out or engineered. As a result, some of the systems have been abandoned in place and control has reverted back to the manual building control systems.

Through lessons learned in failures of these first energy management systems, administrators and manufacturers are now able to design, purchase, install, and maintain effective energy management systems. Within the past five years advances by manufacturers into new, less sophisticated computerized systems have enabled many small colleges and universities to install CEMS. Before plant administrators commit their institutions to a computerized energy management system, they must first decide why they want a system and what the system should do.

This chapter will discuss the different types of CEMS and the various options available. Guidelines are provided to assist the physical plant administrator with the selection of a CEMS, and the advantages and disadvantages of various systems are reviewed.

6.2 PURPOSE

Before any plans are made to install a CEMS, it is critical to decide what the system should do. Criteria should be established regarding the system's

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Valuable research and technical information contributed by Steven Bloom, Senior Facilities Engineer, Eastern Washington University.

payback period, whether the system is to perform functions of maintenance personnel, and whether the system is to be used as a management tool to provide reporting data to administrators.

Control

The control features of CEMS are usually the most important reason the systems are installed. All control functions for HVAC systems can be performed by the CEMS, plus many features not available with conventional control systems. The following are some of the more popular control options:

- Air Handling Unit Set Point. Can reset critical air handling unit limits such as discharge air temperature limits and minimum outside requirements.
- Load Shedding. Turns off fans, pumps, chillers, etc., to reduce peak electrical load and thus reduce power company demand charges.
- Optimum start/stop. Performs night setback of building systems and is programmed to turn mechanical systems on and off based on outdoor air temperature. Most systems run continuously if personnel are not assigned to a building, or time clocks start and stop units according to preset schedules.
- Lighting Control. Turns interior and exterior lights on and off based on class schedules and need.
- Duty Cycling. Turns mechanical systems on and off if space conditions are being met. Shutting down mechanical systems reduces overall electrical usage for the campus. Additionally, load shedding can be achieved if all of the campus fan systems are not operating concurrently.
- Mechanical Systems start/stop. This function varies from optimum start/stop because an operator can start and stop equipment when desired. This function is absolutely necessary if the campus has a chilled water loop or heating loop system. To make full use of this option a monitoring option is also required.

Monitoring

The monitoring feature is as important as the control option. This allows an operator to see what is happening at the building. Chilled water temperatures, room temperatures, pressure drop across filters, and on/off status of equipment are all monitoring functions that are available. All points can be provided with functions that signal an alarm at the central CEMS if set points fall below minimums or rise above maximums. These points can be especially beneficial if experiments requiring right control of environmental systems are being conducted in research facilities.

It is important to define the extent of monitoring required. Monitoring the temperature in every room can be expensive. To reiterate, it is imperative to define the requirements of a CEMS before a wish list of unnecessary points is developed.

Recordkeeping

This option records monitoring information for use in management reports. One of the most useful recordkeeping items is to record energy consumption of the building through BTU, water, gas, electric consumption, electric demand, and steam or condensate meters. This would be most applicable to large campuses with central utilities. Additional recordkeeping information can be used to determine when routine maintenance should be performed. Functions such as run time, filter replacement, etc., are typical recordkeeping functions.

Report Writing

Once all the information is available, it may be beneficial to prepare professional reports for distribution to campus administrators. Color CRT terminals, color graphics, and color printers are available. Again, these options are costly and should only be considered if necessary to assist the administrator with management requirements.

There are several other functions CEMS can perform; however, the above listing indicates the most commonly used. Additional functions such as security systems and fire alarm systems have been integrated into CEMS. Some systems have programs available that can perform all security and fire alarm functions, while others are capable of picking up alarms from stand-alone systems. Security and fire alarm systems are usually monitored by campus police departments. Many of the CEMS available have obtained UL approval. However, local code authorities should be involved in the approval of the systems.

6.3 TYPES OF SYSTEMS

There are as many different types of CEMS as there are needs. As the state of the art in computerized systems has changed, different types of systems have evolved. With this proliferation it has become more difficult to classify computerized systems into different sizes or types of systems. For instance, the CEMS may consist of one central processing unit (CPU) and several field cabinets that provide information to the CPU for processing. The CEMS may also consist of one central CPU that communicates with many field direct digital control (DDC) units, which actually perform controlling functions and can be controlled from the central CPU. On the other end of the spectrum, a CEMS may consist of something as simple as a time clock with a computer chip.

Most existing noncomputerized HVAC control systems are electric, pneumatic, or electronic. All three systems can be readily adaptable to a CEMS. In particular, electronic systems are becoming more popular since they provide for more accurate control and can be easily connected to a direct digital control system.

The two types of points used by virtually all CEMS are analog and digital. The plant administrator should become familiar with this nomenclature, because the types of points used are important when determining how the data collected will be used and transmitted to a central processing unit. Basically, an analog point is used when the input and output varies continuously, such as changing temperatures. A digital point is used when the input or output is to be changed, such as an on/off switch.

Mini/Microcomputers

Many manufacturers produce equipment that can be programmed to start and stop air handling equipment, lights, etc., at predetermined times. These computers usually replace mechanical time clocks while providing additional features not available with time clocks, such as holiday shutdown.

Micro and DDC Computer Systems

Both microcomputers and DDC computers perform building control functions effectively for large and small campus buildings. These systems have more capability than the local computerized-type time clocks and, in some applications, can be tied to centralized computer systems.

Each microcomputer or DDC system is a stand-alone computer capable of performing most building functions, such as HVAC control and lighting systems control. The computers are normally user friendly and can be programmed at the computer by campus personnel. Large buildings may need several of these units to perform all the functions required by the building. This depends on the memory capability of the computer.

Although this type of computer will perform the basic functions required by most buildings, it does not have recording capability nor can it communicate with other computers throughout the campus without the use of a CPU.

Centralized CEMS

This system usually consists of a CPU that is located in one campus building. It communicates with control systems throughout the campus via field cabinets or microcomputers located in buildings. This system has the most flexibility of all computerized systems and affords the greatest cost incentives. Data may be transmitted from the central CPU to the building cabinets by either hard wiring or by telephone lines using a connecting modem. Campus geography should be evaluated to determine which type of transmission system is used.

Some of the major features of a central CEMS that should be considered are listed below:

- Size. The central CEMS can be sized to handle the needs of any college or university. Size, however, is directly related to cost and much consideration should be given before specifying the size of the computer system. Size, for central automation CEMS, is usually tied to number of points required to be monitored and/or controlled.
- Peripherals. There are many hardware options available with a central CEMS.

Monitors, such as CRT screens, are available to display information requested by the user. Several monitors can be connected to one CPU. Color monitors are available and should be considered if color graphs and reports are to be prepared.

Keyboards are virtually mandatory and are used to call up functions, determine status, change programs in the system, or start and stop equipment.

Printers can be used to record present operating conditions, if desired, or to provide hard copies or energy consumption information stored by the computer. Color printers are desirable if management reports are to be created.

Storage may consist of floppy disks, tape, or hard disk type systems that store the programs that operate the CEMS. The CEMS programs are provided by the manufacturer, but a good programmer can modify the manufacturer's program to meet specific campus needs.

- Field Cabinets. Field cabinets are located in the building being controlled and communicate with the CPU. Field cabinets are sometimes "dummy" cabinets. All the computing functions are performed at the CPU and the field cabinet merely acts as a data gatherer. A popular field cabinet is the "smart" cabinet, which is a microcomputer/DDC unit. This unit is capable of performing all control functions, yet it is tied to the CPU which can override local control when necessary. In addition, building systems will operate normally through the DDC unit if the central CPU malfunctions or loses power. These units also reduce the size required of the CPU.

The use of centralized computer systems has been expanded to central processing units that control other central processing units that in turn control other micro or DDC computer systems. The key to selection, as previously stated for a CEMS, is to define the need of the system.

6.4 ADVANTAGES AND DISADVANTAGES

A large computerized energy management system is capable of performing almost any function required of the physical plant administrator. That does not mean that every college and university should have a central CEMS. A small campus may only need a DDC system for one or two buildings and may even use a minicomputer for a small building system.

Mini/microcomputers are effective replacements for building time clocks and on a simple control system may be all that is necessary. These systems are fairly inexpensive, $100 to $1,000, and should be considered first before pursuing the installation of a larger CEMS. Obviously, these systems are limited in capability and cannot perform load shedding or other more sophisticated requirements.

Micro/DDC systems can perform any control function for a building. These systems cannot, however, provide for centralized load shedding or control unless they are connected to a centralized CEMS. The cost for micro/DDC system ranges from $1,000 to $25,000.

The centralized CEMS can perform all required functions and is the most versatile. Defining the specific needs of the institution are critical as costs for these types of systems begin around $25,000 and can go well over $1 million. Even a large institution should not blindly purchase a large CEMS if staffing is inadequate to operate and maintain the system.

Any institution that has decided to install a CEMS should commit at *least* one individual to be thoroughly knowledgeable in the operation of the CEMS. With the installation of computerized systems plant administrators learned that if the maintenance personnel do not accept the system and know how to operate it, within a short time the system components will be disconnected and the control systems will be back in manual operation.

Maintenance of the CEMS should also be considered before purchase. Large systems require someone on the campus knowledgeable of the systems and may also require a service contract with the manufacturer. The cost for the service contract should be considered when bidding and purchasing a CEMS. An institution may be able to purchase a more expensive CEMS that requires less maintenance than a cheaper system that requires more.

Once a CEMS is installed, future additions to the system will prove extremely costly since manufacturers know their product is single-sourced for that institution. For this reason much thought must go into the specifications before the system is put on the market for bidding. Bids can be requested from contractors to provide unit prices for installing points at future dates, if escalation clauses are included in the specifications. Plant administrators must decide if they should wait until the department can afford a CEMS that will perform many control functions or whether to install microcomputers in individual buildings with the hope of connecting them into one CPU in the future.

Tying several microcomputers or DDC systems to one CPU unit is one of the most controversial issues in the CEMS market today. Some manufacturers will say their CPU is compatible with most DDC systems and microcomputers, while others will say their system is only compatible with their own. Since the market is changing rapidly, this particular criterion must be evaluated by plant administrators before pursuing a CEMS.

The obvious advantages of owning a central CEMS include the capabilities to provide campus load shedding when required, recordkeeping and tracking of energy consumption, and the capability of producing management reports. The installation of a CEMS will not normally replace any maintenance personnel; however, it may change the classification of a few people. For instance, the need to have someone run around the campus turning on and off chillers and HVAC systems will be eliminated, but the CPU should be monitored at all times by one individual.

6.5 SELECTION CRITERIA

When considering the installation of a CEMS, plant administrators should hire a knowledgeable engineering consultant to evaluate what type of system or systems the institution should install. Many engineering firms design mechanical/electrical systems but know little about computerized energy management systems.

Immediately after bringing the consultant on board, the CEMS requirements should be defined. Exactly what does the physical plant department require to be monitored or controlled? If there is a budget for the CEMS, the consultant should be provided this information. Ideally, the consultant should determine which type of system would best serve the institution based on payback and campus functional need.

If a centralized CEMS is chosen, where will it be installed? Most CPUs require (or manufacturers prefer) that the CPU be located in an air conditioned space. Manufacturers' literature should be reviewed before determining the location of the unit.

The microcomputer/DDC system and CPU should have battery backup. In particular, centralized systems should have battery backup in case a local power failure occurs where the CPU is located. Fail-safe manual controls should be maintained in case of a computer failure. The manual controls will enable the mechanical/electrical system to continue operating.

What kind of flexibility or expandability will the system require? Will there be a need to add to the system in the future or will this unit handle a campus that is not expected to expand within the next 20 years? Should the CEMS have a large CPU with "dumb" field cabinets or should there be a small CPU with "smart" field cabinets? All of these questions require analysis by the physical plant administrator and engineering consultant.

The type of communications system should be analyzed. Options include hard wire from building to building back to the central CPU, or phone lines using a modem that provides communication between a field cabinet and the central CPU. Some systems are available that use existing electrical wiring in the building to communicate signals from the equipment being controlled to the microcomputer. Each communication mode has its limitations, advantages, disadvantages, and cost implications that vary with each installation. All should be evaluated by the engineering consultant.

Installation of a CEMS is not the panacea for every institution's energy demands. Small institutions may be able to use maintenance personnel to perform manually many of the functions that could be done by a CEMS. This is an option to remember when the consultant is hired to perform the analysis.

6.6 SUMMARY

Computerized energy management systems can provide valuable cost savings and energy reductions for colleges and universities. Physical plant administrators should not blindly believe everything manufacturers claim and purchase systems based only on that information. Before proceeding with the purchase of any CEMS, a good engineering consultant should be hired to evaluate the type of system that best suits the campus *needs*. The key word is *need*. The plant administrator must define the institution's needs when considering the purchase of a CEMS.

The budget for the project should be defined. If there is no budget, what criteria will be used to determine the size of the system to be installed? Should the size be based strictly on what the administrator knows is needed, or should the consultant perform an energy analysis to determine what system could be installed with a reasonable payback?

If there is a limited budget, what flexibility should be built into the system? What kind of capability should the system have to expand—to double or triple its size—over the next ten years? If expansion is desired, what kind of safeguards will be designed into the system to prevent noncompetitive pricing by the manufacturer in the future?

Physical plant administrators should conduct, as much as possible, their own research into the options provided by various manufacturers. Sticking with major manufacturers may prove beneficial when requiring service for the CEMS. More importantly, however, the kind of local service available is critical.

The administrator should call other colleges and universities who have similar systems. This evaluation can be extremely important in determining which manufacturers provide good service after the sale.

Computerized energy management systems are here to stay. These systems can be a valuable management tool for monitoring and controlling the dynamic conditions that exist in all buildings. Before purchasing any CEMS, conscious decisions should be made regarding the main purpose of the system. After the decisions are made, all the available options should be reviewed and only those necessary should be purchased.

CHAPTER 7

Computerization of Plant Operations

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7.1 BACKGROUND AND PURPOSE

The rapid evolution of computer technology is making the use of computers in the plant departments of colleges and universities an attractive alternative to manual recordkeeping. The combination of declining student enrollment, limited funding, and upward spiraling operating costs make it imperative that institutions operate more effectively with fewer resources. And because the plant operation consumes a significant portion of any institutional budget, the plant administrator is under constant pressure to "make do" with fewer means. Automating the paperwork process is a good management strategy for attaining the kinds of savings mandated by institutional authorities. But even more important, computerization is an effective tool for better managing a plant operation.[1]

The goal of better resource management is surely one to which all good plant directors aim. Deferred maintenance, though always a challenge, has reached crisis proportions at many institutions of higher education. Though energy costs have stabilized, prices remain high and finding ways to control consumption continues to be an important administrative objective. Carefully managing dwindling maintenance funds by keeping close watch on authorized work orders is another way in which a plant administrator can make the most of limited funds. The correct prioritization and scheduling of necessary maintenance in order to assure that vital projects are completed is yet a third major aim. These goals, and many others, are more easily achieved with the use of modern data processing equipment.

Computers have always had the theoretical capacity to perform these types of functions, and computer technology has been used by plant departments for a number of years. But until recently the cost of the necessary equipment was

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Valuable research and technical information contributed by Howard Cihak, Director of Plant Operations, Gallaudet College, and Richard S. Jacobs, Manager of Operations and Systems Development, Washington State University.

too high to be economically justified except at the largest institutions. Involvement with computers meant purchasing expensive equipment, hiring specialized staff to operate the machines, and developing custom software to operate the systems. However, it is now possible to acquire small, powerful computers at a modest cost that have the same capabilities as mainframe computers of the early 1970s. Even persons with no technical background can successfully join the computer revolution because of the efforts of equipment and program manufacturers to make their operations user-friendly, or easily understood by novices. In view of these developments and the potential economies offered, it would seem desirable that the use of computers at least be carefully evaluated.

The decision to computerize plant operations should be no different from any other decision. The expected costs must be weighed against the potential savings that would be incurred. Unfortunately, a comprehensive evaluation is no easy task to perform because the responsibilities of plant departments are so diverse—ranging from the handling of standard maintenance functions to the operation of the campus phone system. In such organizations it is difficult to keep up with daily problems let alone assess the potential savings of computerization. Tasks tend not to be straightforward or singular. One individual may perform a multitude of diverse tasks or several individuals may perform pieces of one task. This makes it difficult to assess the possible effects of automation on worker productivity.

Yet the needs of the plant department must be the paramount consideration. There are many good reasons for automating:

- The manual systems currently in use have become burdensome or outdated.
- New reporting requirements cannot be met with current resources.
- There is a need to make the plant department operation compatible with other campus departments or information systems.
- Plant department operations could benefit from better management through more complete and timely information.
- Institutional growth has outstripped the plant administrator's ability to manage the campus facilities in a proper manner.

Whatever the reason or reasons for embarking upon computerization, the ultimate goals should be formulated and kept in mind. Otherwise the project could be sidetracked by issues tangential to the goals. Or it can become so complicated and confused that the result will be something that does not fully meet the department's needs.

Arguments are sometimes advanced for postponement of computerization since the price of hardware (machinery) and software (programs) continues to decline at a rapid rate. At the same time the power of the new machines increases at a phenomenal rate. Due to the fast pace of technological advances, data processing equipment is becoming obsolete almost as soon as it is installed. However, new and better software and hardware will certainly continue to appear on a regular basis. Waiting for the optimum combination of cost and level of technology is likely to result in never acting, thus losing out on the savings and management benefits that automation can confer on the workplace. Evaluations of cost effectiveness must be based on the current state of the technology and cost.

Ignorance of developments in the computer field may explain the reluctance of some plant administrators to move into the computer era. Of more importance may be the fear of the unknown that this lack of experience generates. The information in this chapter is intended primarily for the person who has no prior experience in the computer area. Those who have experience and are aware of the benefits to be reaped from office automation can perhaps glean a new idea that can be applied in future efforts.

7.2 POTENTIAL APPLICATIONS

One of the first things plant administrators should ask of those who advise them to computerize the facilities management operation is what types of things a computer can help them do better.

While there are innumerable things that can be done by computers, the applications listed in this chapter represent those most commonly in use around the country. Managers will have to evaluate which of these suggestions might be relevant to their operation. As a general rule, however, the activities most successfully mechanized are those that involve a lot of repetitive work of a structured nature or that require the manipulation of large amounts of quantitative data.

Word Processing

Word processing is popular today in the field of office automation, and with good reason. There are a large variety of machines and software available that permit converting from manual typewriters to electronic document processing. Simply put, a word processor allows a typist to type a document or letter, make revisions easily on the video display screen, print a copy of the final result, and then save the document for later use or further revisions. The most time-consuming process for any typist is the process of making revisions to a document. Word processing makes this operation much simpler. In fact, many of the newer systems have built-in dictionaries that will examine documents for misspelled words and mark them for correction by the typist. By manipulating a document electronically in this way and storing frequently used form letters, support staff productivity can increase from 30 percent to 60 percent, depending on the type of work performed.

Word processors allow a typist to produce better quality documents and to perform tasks that were previously too time consuming or complicated. While support staff are often reluctant at first to give up their electric typewriters, they will, after using a word processor for a short time, almost universally applaud a manager's wisdom in purchasing it.

However, one word of caution is in order concerning such systems. Every effort should be made to standardize both hardware (equipment) and software (programs) within the office and even within the institution as a whole so that diskettes (the medium on which documents are usually stored) and operators are interchangeable. Without such standardization an office or institution can become a virtual tower of Babel in which a document on one machine cannot be used on another.

Payroll/Personnel

Payroll/personnel functions are another area in which great potential exists for saving time and human energy. Most plant offices tend to spend a great deal of time manually processing time cards and then transferring the data twice—once to payroll reporting sheets and a second time to job order cards. It is a relatively simple matter to reduce this sort of duplication by entering time card information into a computer once. The computer then automatically generates both types of documents on a regular basis. Such an operation avoids the need for clerical staff to pore over long sheets of numbers, adding columns of figures several times to assure that no arithmetical errors have crept into the totals.

Other obvious applications of a similar nature are using the computer to track accrual of vacation and sick leave or to generate productivity reports, arranged by worker name, for managerial use. Care should be taken that the system and procedures adopted are compatible with and approved by the campus personnel office in order to avoid unnecessary problems.

Financial Data Management

Managing financial data is an essential function in any plant department. It is obviously important for plant administrators to be fully informed about the fiscal integrity of their department. At a minimum the plant administrator must have information on expenditures to date, budgeted amounts, and projected expenditures for the rest of the fiscal year concerning those accounts for which he or she is responsible. Additionally, the plant director should be fully informed of maintenance funds available for use, how many dollars have been committed to date, and which work orders are still outstanding or expected. This can be done efficiently through a computerized work order system to keep track of all maintenance expenditures by work order on a daily or weekly basis. See Part III: Maintenance Management, Chapter 2, "Maintenance Management Systems" for further details.

Maintenance Scheduling

Maintenance scheduling can actually be used to cut down operating costs over the long term by permitting the establishment of a preventive maintenance program that is integrated with the work order tracking systems. But more important in many cases are the other management benefits that can be obtained through use of such a system. An automated tracking system, for instance, can assist administrators in projecting workload requirements in terms of man-hours needed for certain tasks. It can also categorize costs on a per-job basis and help administrators analyze whether additional repair of an item is cost effective. With a computerized scheduling system a plant department can better manage its logistics by clustering jobs to more efficiently dispatch workers to their job sites. See Part III: Maintenance Management, Chapter 8, "Use of Computers in Maintenance Management" for further details.

Inventory Control

Computers have been used for the inventory function for many years. The applications for the plant department are numerous. By keeping an automated record of all items in a warehouse, entering withdrawals and deliveries as they occur, and setting minimum and maximum reorder amounts, a storeroom operation can be made to operate at peak efficiency.

In addition, an inventory system can sometimes be linked with a preventive maintenance program in such a way that the two systems exchange data to the benefit of both. For instance, preventive maintenance work orders can be printed with a list of parts necessary to accomplish the work and which the computer has verified are currently available in stores. An integrated system of this kind can be used to project future parts needs based on the preventive maintenance scheduled during the month. The computer can then issue a report to the stores supervisor of any shortages that are likely to occur. In this way delays caused by low materials stock can be prevented.

Potential exists for the plant department's inventory system to exchange data with the institution's purchasing system as well. By working out such an arrangement, additional recordkeeping steps can usually be avoided. See Part III: Maintenance Management, Chapter 5, "Management of Maintenance Stores" for a detailed discussion of computerized stores inventory.

Key Control

The control of keys at institutions, discussed in Part IV, Chapter 9, is a matter to be grappled with regardless of campus size or type. However, key control in and of itself is a relatively simple computer application. By keeping records for keys on the computer it is possible to know precisely who has access to certain areas or whether individuals scheduled to leave the campus have returned their keys. More important, key control staff will always have access to records that can be used when requests are received for new or replacement keys. A program of this sort that tightly controls key access can play an important role in securing the campus from unwanted intruders.

Energy Management

Energy management applications are by now well known and appreciated by plant administrators. In fact, an energy management program is one way to introduce the concept of computerization to the plant department office. It can often be implemented on two different levels. The first and least expensive level consists of using a simple unit, often wall mounted, that will operate HVAC systems according to a simple set of instructions provided by the user. Such units, while effective, are also limited in many ways. Rarely will the low-cost units, for instance, be capable of such advanced operations as load shedding, duty cycling, temporary overrides, or remote alarm signaling. Centralized reporting of system activity is usually not available in such primitive systems. For this reason, the popularity of larger, more sophisticated and expensive energy systems is growing.

In searching for an automated energy management system, several factors should be considered. First, the system chosen should be designed to work efficiently in a multiple-building or multi-campus environment. Second, the vendor selected should be carefully matched to the institution's needs. One of the best ways to ensure this is to obtain a list of prospective vendors' customers. Then visit their facilities to see how well the system works in the field. Concentrate on those installations that are similar to yours in size and arrangement. Third, avoid systems that are not user-friendly or that may be so complicated that the plant department will become totally dependent on one vendor for hardware and software support. With so many good systems on the market, a buyer can afford to pick and choose.

Life-Safety Monitoring

In many cases life-safety monitoring can be integrated into a centralized energy management system. The use of a computer to monitor the status of fire and smoke alarms in buildings in combination with other security devices can greatly enhance an institution's ability to respond to emergency situations. For instance, in a fire alarm situation a dual life-safety monitoring/energy management system can instruct the HVAC system to close all fire dampers and shut down the air handlers to prevent smoke from spreading throughout the structure. Many such systems can be set up to simultaneously transmit alarm information to both the plant department and security offices. Dual alarms allow for the swift dispatch of aid in the event of a real emergency. They also eliminate much of the guesswork that can surround the question of precisely where the problem is located.

Deferred Maintenance Identification/Prioritization

Identifying and prioritizing the deferred maintenance of facilities is a relatively new computer application that is beginning to receive greater emphasis as the problem of postponed upkeep becomes more severe. While the task can be handled a number of different ways, the computer can be used as a giant filing and sorting machine to identify building systems that require repair or modernization. A priority number is also assigned to each backlogged maintenance project to differentiate the less acute problems from those requiring immediate attention.

Institutional authorities can also use such a system as a long-term planning tool. By enlisting the aid of the computer, institutional officers can stay apprised of the current condition of their plant as well as the amount of money required in future years to maintain the integrity and usefulness of campus structures. Plant administrators have used these techniques successfully to obtain greater funding for building renewal and replacement.

Construction Management

Construction management is a different kind of scheduling application that lends itself to computerization. While not a part of all plant operations, many institutions have begun experimenting with internal construction management as a way to save money on simpler building projects. In these cases a college or university can often save money by acting as its own general contractor. However, the more complex the project and the more subcontractors involved, the more the aid of a computerized project management system is required to mesh the various contractor schedules. In this area a plant director can learn from general contractors and construction management firms that almost universally use modern computer technology to help them manage construction projects.

7.3 HARDWARE, SOFTWARE, AND THE HUMAN ELEMENT

There is a tendency on the part of newcomers in the computer field to focus on aspects of the hardware, or machinery, to the exclusion of all else. Many technical publications and much of the manufacturers' literature confine themselves almost exclusively to discussions of the technical capabilities of the hardware on the market today and encourage this inclination. However, for administrators to successfully computerize operations, they must take a much broader view of real needs. What they will be putting together is not a simple amalgam of shiny hardware or dazzling software, but a tool designed to accomplish certain tasks. The manager is thus putting together a system consisting of hardware, software, and the people who must work with it. All three parts of this triad must be balanced and work together to produce the desired results.

Unless the basic instructions that the computer receives—the software—are capable of doing exactly what is wanted, the system will never operate to the satisfaction of management. Similarly, the hardware can never produce a particular result, such as a report or a recordkeeping operation, unless the equipment is physically capable of performing the task. Administrators need to remember that once the hardware has been chosen, that decision will begin to limit the range of software from which they can choose. At the same time, the software can also be a limiting factor in getting the hardware to do the tasks desired. The two must be carefully matched with one another so that neither one overpowers the other.

In addition to these general principles, there are a number of other factors to be aware of when shopping for hardware. Hardware must be compatible with the software that is to be bought or developed. If the software package of choice has been written for a certain machine, it may not be compatible with other brands of computer equipment. More important, be certain that the language in which the software has been written is available for the machine selected. For example, there are many different versions of the BASIC computer language. While many of the commands are the same from one dialect to another, there are sometimes significant differences between them. A program written in one BASIC dialect usually cannot be run on a machine that uses another dialect without considerable modification. Many software packages come in numerous versions with a different one for each manufacturer's hardware. Be certain that the package purchased comes in a version compatible with the hardware you choose.

A second point to keep in mind is whether the hardware being considered is compatible with other machines with which the plant department may need to communicate. This factor is especially important in the area of word processing. Every effort should be made to ensure that the hardware selected is compatible with other hardware in general use on campus. Otherwise, it is possible for the plant administrator to become isolated from other administrators as they exchange documents via electronic mail systems or use their machines to link up with the institution's central computers. That may not be a significant sacrifice at present, but it may be critical to future institutional requirements.

Plans should be discussed with campus administrators who are responsible for data processing to ensure that the plant department's purchase is compatible with the institution's long-range planning. Even more important, plans should be discussed with fellow administrators who may be interested in doing the same kinds of things. There are enormous benefits to such exchanges for all parties concerned. Administrators can accomplish far more by such cooperation than if they simply proceed on their own.

A third consideration when choosing computer hardware is service. It should be determined with certainty that maintenance is readily available for the kind of hardware purchased and that the vendor who sold it is concerned with the customer's satisfaction. Locally available service is the ideal, but may not always be possible—especially in towns and smaller cities. At the very least, service should be available within a day of when the problem is reported. Consider service contracts for high-cost mechanical parts that are vital to system operation. If service contracts are unavailable for the hardware of first choice, be wary. It may mean that the manufacturer is concerned primarily with selling finished units and does not have a real commitment to the product line.

Finally, the hardware selected should be ruggedly built and easy to operate. Beware of keyboards or display screens that are not designed for day-to-day office use. Operator comfort should be a primary factor in the design of computer equipment for the office. Features such as display screens that can be tilted at any angle or detachable keyboards that can be placed for maximum operator comfort are common. In short, staff should not be saddled with hardware that is designed without these factors in mind.

Staff involvement in the process of selecting a system should not be discounted as mere window dressing. The staff must feel comfortable with this new addition to the office environment and also should believe themselves able to make good use of it. Some hardware and software systems are simply easier to use, operate, and maintain than others. Often staff members are better able than the manager to see the operational shortcomings of certain systems. For instance, operator comfort in an application like word processing cannot be ignored since comfort can either enhance or degrade the productivity gain. As a result, the earlier staff are consulted and made part of the selection process, the more successful the final result will be. Without a commitment on the part of the staff to make the new computer systems work, the system's full potential will never be realized. On the other hand, with staff support even flawed systems can be made to work well.

7.4 MAINFRAME VERSUS DEDICATED SYSTEMS

A major decision that must be made early in the process of mechanizing the plant department is whether to implement the systems on a mainframe computer—a large-capacity, complex computer system based on one central processor—or a small computer system to be used only by the department. The latter kind is usually referred to as a dedicated computer system. Both systems have certain advantages and disadvantages attached to their use. The use of the campus mainframe computer is often mandated for certain financial tasks, so there may be no real choice in the matter. However, institutional authorities should be consulted on any policies that may affect a plant administrator's decision.

Implementing office automation on a mainframe computer has certain advantages as well as disadvantages. The key advantage is that individual departments do not have to worry about maintaining hardware and software. That is usually the responsibility of the central computing system staff or the vendor supplying computing services. For example, if a new reporting format is needed or a software update is necessary, the plant department does not have to do the job. Instead, the department would simply draw up the necessary specifications and the computing center staff would carry out the task. Thus, such an arrangement is ideal for persons who have no computer experience and no desire to be concerned with how they operate.

In addition, a mainframe computer is capable of doing much more complex functions and handling a greater quantity of data than smaller computer systems. One example of how this advantage can be exploited revolves around the integration of files. With the mainframe computer the possibility of integrating the plant department's systems with other institutional data bases—such as the accounting system, payroll/personnel system, or purchasing files—is usually far easier to accomplish than with dedicated systems. That is because the plant department data resides on the central mainframe along with other institutional records.

Accompanying these attractions, however, are some significant disadvantages and frustrations. The user will be completely dependent on others to see that the system works properly. These individuals may not be responsive to user needs. A feeling common among users of mainframe systems is that they do not control their own destiny and that the central computing staff does not really care about their problems. They often have difficulty getting enhancements to a system or obtaining data arranged in an unusual format for a specific report.

The rates charged for this kind of work may make it almost impossible to change a system once it is in operation. Many data processing shops have backlogs of three to six months' worth of new work at any particular time. Thus, changes are almost impossible to implement in anything less than a six-month period. Additionally, user rates are uncontrolled and overhead charges often run high for use of mainframe computer time. Since rates fluctuate, projecting a department's future operating costs can be difficult. Finally, if the central computer gets overloaded with users, there can be operational problems as well. Should this happen, the department's work may suffer significant delays.

Many of these problems can be avoided by using a dedicated local computer system. Such a data processing arrangement eliminates any problems with competition with other groups for computer resources. Since the computer is designed to serve one department's needs rather than those of multiple user groups, delays and lack of flexibility can be avoided. Hardware can be tailored to a specific application rather than modifying the software to be usable by a mainframe. With a dedicated computer system the user is truly the master of his own destiny since the machinery is on site. Thus, changes can be executed in-house rather than relying on outside programmers. Work can usually be done much more quickly and efficiently. And operations costs are essentially fixed. Since both the hardware and software have already been purchased, the administrator has a good idea of what the day-to-day costs will be both now and in the future. Costs, consequently, can be well defined ahead of time. The department need not be placed in a situation where it must subsidize an inefficient central computer shop.

Along with the pluses of dedicated systems are some minuses. Most obvious is that the maintenance of hardware and software are now the department's concern. This means that hardware failures that slow down plant department operations are now the administrator's headache and not those of the computer center. Initial installation and alterations to software are also now in the purview of the plant administrator.

The costs of an operation of this sort can often be high, with a full-time staff member assigned to the operation of the system. Another part of the downside is that backlogs can occur in such one-person operations just as easily as in large computer centers. Finally, setting up a department's dedicated system often binds the user to a single vendor for hardware and software, leading to another type of dependence, since mini or microcomputer system hardware is often less interchangeable than mainframe equipment.

Administrators ought to weigh carefully the advantages and disadvantages of each option and choose the one that best fits their predispositions, experience, and situation within the institution. Only by evaluating these attractions and drawbacks in light of institutional policies and experience can the proper decision be made.

7.5 DEVELOPMENT OPTIONS

While the cost of hardware is perhaps the most visible consideration in any attempt to computerize operations, it is only one factor to weigh. In fact, many of the costs involved in a data processing start-up are hidden from view. A special effort must be made to identify these costs and to include them in the decision-making process. A major example of a hidden cost is the time required to develop and/or install a software system that meets the department's specifications.

If a department develops its own software, managers must recognize the cost of hiring a programmer to develop the system, the staff time required to brief the programmer on current methods of operation, the time needed for start-up (which can be considerable), and the almost endless adjustments or changes to the software that are a part of the data processing operation. Skimping at any one of these stages can lead to later problems. The simple fact is that good programming is not cheap. Hiring a part-time student to write a system to handle the department's needs may seem to be an ideal solution, but rarely will such arrangements prove satisfactory. System development is a full-time job. If administrators embark upon such a project, they must be prepared to pay for a first-class job.

Of course, it is not necessary to write custom software. Buying or leasing software from an outside vendor is a cost-effective solution to many software problems. In other words, it makes little sense to spend a great amount of money to develop software to perform certain functions when such programs are already available at a reasonable cost. Not only is purchasing commercial software less expensive, but it enables users to get a system operational more quickly than if they started from scratch. Many of the packages available are more refined, flexible, and sophisticated than an organization would be capable of producing on its own. As a result, organizations not only get a less expensive product installed in record time but a better product than they would be able to otherwise obtain.

Whether you hire an outside firm or employ a resident programmer to write a custom program, you will probably be working with an individual who has no expertise in plant administration. That person must rely on information volunteered by staff. Similarly, department staff, who are not typically computer experts, are likely to omit important facts that can make a great deal of difference in terms of writing programs for plant applications. Where there are communication gaps between the software writer and plant department staff, there are bound to be oversights. Oversights of this kind can be costly in terms of time and money if the programmer must rewrite whole portions of a program to rid it of problems caused by communication barriers. Clearly, fostering close cooperation between data processing specialists and plant staff is the key to averting expensive mistakes.

Even in situations where you cannot find a proper match between your choice of software and the hardware you may already have—or be mandated to obtain by the institution, there are generally ways around the problem. First, evaluate the difference between the software you most prefer and the best software that is compatible with your present hardware. Often the difference between the "best" and the "second best" software is marginal. If that is the case, it may be most advantageous to accept the second choice rather than get into the system development business.

Second, be sure to evaluate carefully the disadvantages of obtaining new hardware on which to operate your software of first choice—ignoring the question of institutional compatibility. If the plant department's current hardware is more than four years old, it may be time to consider replacement with more modern equipment anyway. Even if the hardware needed for the preferred software package is not compatible with the predominate type of hardware available on campus, it may not be a great disadvantage for the department to go its own way. It all depends on how much interaction is required between the plant department's hardware and other organizations within the institution.

Finally, a software vendor will often be willing to rewrite a software package in a language compatible with a customer's current or proposed hardware arrangement. This service will no doubt carry a price tag. However, many vendors are willing to negotiate a contract with a reimbursement clause in which a client receives payments based upon how well this new version of the software sells. Having software available in several different versions is usually in the vendor's best interest since it broadens the potential market for the product.

One other alternative is available to the manager. While traditional computer languages were once obscure and difficult to learn, a new generation of higher level languages has emerged for today's user. These higher level languages are sometimes referred to as data base management systems (DBMS) and are actually a cross between traditional computer languages such as BASIC, COBOL, or FORTRAN and user-friendly word processing packages. These data base management systems allow users to develop applications on their own with little expenditure of time or effort. They are usually highly structured and focus specifically on the needs of small businesses that use them for accounting, order processing, mailing lists, customer billings, and payroll functions. Thus, they would be excellent for most facilities applications with the exception of areas such as energy management and word processing.

In order to understand the possibilities of such a system it is necessary to first be clear about what a data base is and how it functions. A data base is a collection of information on one or more subjects that has been put into a form that the computer can read and process. Usually multiple users can access this data base for their own purposes and may feed new information into it.

The classic example of a data base is one clustered around personnel information. A personnel data base is a collection of information on each employee at an institution. It usually includes such data as name, address, department of employment, current salary, job title, office address and telephone number, current accumulated vacation and sick leave, date of employment, and other information that may be required for an institution to process its payroll. The data base also identifies where employees work and the type of work they do.

This base of information can, in turn, be used by many different organizations within an institution for their specific purposes. For instance, the payroll office will use part of the information to process the employee payroll. Administration may use some of the information to establish staffing levels for various divisions of the institution. The staff benefits office may use part of the data base to determine the eligibility of an employee for certain benefits. In addition, they may use the office address information to compile an employee directory for internal office use.

Of course, these are just examples. Data bases come in many different forms and sizes. The tie-in to facilities administration is that such entities as the job order system, the stores inventory system, or the preventive maintenance system are nothing more than data bases. The information stored in them is just like any other file from which certain reports or notices are preiodically produced.

Most data base management systems consist of three major parts. The first allows users to develop data entry formats for everyday use in adding new information to the data base; updating, changing, or deleting information stored there; or simply looking at data in the data base. The latter step is often called an inquiry function.

The second major part is a command language that can be used to perform certain functions using information within the data base. For instance, one command sequence may be used to post expenditures to a certain job order as they are entered into the computer. Other commands may be used to retrieve data from several different files within the data base, make certain logical connections between them, and then merge the information. What results is a whole new file that consists of information extracted from several different places within the data base. The new file can later be used to produce a customized report or to support a new data-base application.

The third part of most data base management systems (DBMS) is a custom report generator. Computer systems contain "menus" or lists of files, libraries, or programs. Custom report generation is usually a menu-driven function that allows an individual user access to certain parts of the data base in order to produce custom reports of a particular format quickly and easily. The user decides what information he or she wants to see and how it should be displayed on a sheet of paper. The computer does the rest. Report formats of this sort can ordinarily be saved for future use. Users of this feature need not have programming skills or familiarity with computers.

By obtaining a data base management system, a department can develop its own applications just the way it wants them. The purchaser will not require a programmer to install or maintain the system because of the user-friendly nature of such packages. Thus, plant administrators can get the best of both worlds by employing software tools to allow staff to do their jobs quickly and efficiently. A DBMS can also save the department the expense of hiring a resident programmer since a present staff member can usually be trained to operate the system.

A data base management package is a viable alternative to either purchasing a commercially available software package or developing a plant department's own applications with standard computer languages such as BASIC or FORTRAN. However, managers need to shop wisely for the proper DBMS package since new ones are introduced almost monthly. Managers should look for features that are needed for plant administration, easy-to-use instructions, and the capacity to handle the numbers and types of information the department will need to process.

When comparing DBM systems, examine all three parts to make certain that they are equally good. For example, some systems may have excellent report generators but poor command languages or data entry functions. Do not take for granted that if one part of the DBMS is exceptionally good that the other two parts are of equal quality. Efforts should be made to consult with others on campus who are already familiar with DBM systems or use them in their office. They can usually offer good advice on the kinds of things to look for in a system.

If you use a DBMS to computerize manual recordkeeping practices or are having a custom program written, it is usually advisable to refine manual practices before attempting to transform them into a computer-based process. A well thought out manual system is easy to convert into a computer-based system. However, a poorly defined and documented manual system will not suddenly become efficient and easy to use simply because it has been converted into a computer-based format. Once all the ambiguities and shortcomings of the manual system have been resolved, management can begin thinking about mechanizing procedures. Unless managers are willing to take the time necessary to test the new system in manual form first, they are gambling with the morale and efficiency of their department. Put simply, the plant department office is not the place to experiment with untried solutions. Such experimentation runs the risk of giving the impression that any failures are the fault of the computer rather than the logic of the software. That can sour staff on the whole process and make any further attempts at modernization difficult, if not impossible, to implement.

7.6 CONCLUSION

The workplace in the United States is experiencing a revolution in the methods and tools used to carry out daily tasks. Plant department offices are not exempt from this phenomenon. In fact, the introduction of inexpensive computing equipment to the marketplace will make the computer, in some form, an absolute necessity in the office of the future just as the electric typewriter was in the office of the sixties.

Managers who recognize that the computer is nothing more than a tool that can be used to increase the productivity of a department will be able to approach office automation from a rational perspective. As such, the purchase and use of a computer can be evaluated in much the same way as any other type of equipment used by the department. Just as managers would consult with others on the purchase of an HVAC system, they should not hesitate to do the same with the computer. After all, staff will be the ones who will have to use it on a daily basis. If they are not confident of its worth or quality, any mechanization effort will likely fail. The sooner managers become aware of this dimension, the better able they will be to use the new technology and teach others to use it.

The perceptive manager will realize that on the way to this new office environment the going will not always be smooth. As in any rapidly developing field, computer technology has its problems and limitations. And, because new products are being developed almost on a daily basis, it will take some time before there is any real standardization in this new arena. The trend points toward hardware and software that will be more and more powerful but equipment whose size and cost will continue to shrink. However, anticipation of better, cheaper equipment should not deter organizations from using the equipment of today. Delay can only make the inevitable transition more difficult to deal with.

END NOTE

1. For an in-depth treatment of how computerization can be directly applied to physical plant management, see Earl W. Hawkey and Joseph Kleinpeter's *Computerized Management of Physical Plant Services* (Washington, D.C.: Association of Physical Plant Administrators of Universities and Colleges, 1983).

CHAPTER 8

Transportation

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As enrollments at institutions of higher education grew from the 1950s through the 1970s, campuses expanded several fold in land area. Accompanying that movement was an expansion of services, such as extension work, that colleges and universities rendered to the public. During the same period off-campus research work proliferated. One outcome was that vast quantities of general supplies had to be delivered regularly throughout the campus. Departments of facilities management were not immune from the demand for more transportation. The personnel and materials that they required for daily transport to operate and maintain campus facilities increased as well. The net result is that despite increases in student numbers and new facilities, transportation requirements have increased at an accelerated pace.

The function of a college or university transportation service is to provide for the transport needs of the institution in an economical manner. This does not mean that each and every demand must be met. Rather, there must be a balance between economy and convenience to users. The aim is to provide for an optimum balance between the two. This chapter discusses the functions of an institution's transportation service. In addition, it describes how to set rates.

Throughout the discussion only commonly used vehicles are considered. Specialized mobile equipment such as graders, bulldozers, cranes, backhoes, mowers, ditchers, and forklifts used by the facilities management department and equipment for college or university farms receive only limited treatment since they are not part of the transportation service. The same is true of an institution's bus service. Though a facilities management department may operate the service and maintain the equipment once it is established, the determination of its feasibility and governing policies more appropriately lies with the student services division and the business office.

8.1 FLEET OWNERSHIP AND OTHER OPTIONS

Ownership

Ownership of vehicles and supporting equipment calls for high initial expenditures for their purchase. Maintenance will later require either extensive commitments in the way of facilities, equipment, and staff or a capital outlay for a maintenance contract. The large fiscal outlay may, in itself, pose a problem for many institutions. An important factor to consider when contemplating outright purchase is that long-term amortization necessitates accurate long-term projections of needs. Another factor to take into account before buying is whether or not there is uniform demand throughout the year. It is difficult to justify ownership of vehicles that may sit idle a substantial portion of the year such as during summer months when most institutions operate at a greatly reduced level.

Lease or Rental Options

In recent years leasing motor vehicles has become more popular. Its current popularity stems from the growing number of commercial leasing firms in the market and the wide variety of programs they offer. There are several advantages to leasing. A minimal initial investment is required and the remaining cost is distributed uniformly over the lease period. Maintenance facilities and equipment can be eliminated if full-maintenance lease programs are available. Some lease programs offer an arrangement whereby the customer assumes full ownership of the vehicle at the end of the lease period, while others permit buy-out by the customer at the end of the lease. In general, leasing or renting is often a viable economic alternative to institutional ownership under the following conditions: If the vehicles are needed only infrequently to meet periodic peak requirements, or if only highly specialized vehicles are needed on occasion. The decision to own or lease should be made on the basis of anticipated use, comparison of ownership costs with lease or rental costs, and the availability of vehicles for lease or rent when needed.

Use of Privately Owned Vehicles

A common practice, particularly at small colleges, is to reimburse individuals for use of privately owned cars driven on official travel. Payment is typically based on a mileage rate. Most state institutions have an established rate that applies to all state agencies. The use of privately owned vehicles is frequently authorized when demand exceeds fleet supply or when an employee wants to combine official and personal business on the same trip. An example would be when an individual takes a vacation trip in conjunction with attendance at a professional conference.

8.2 BASICS OF PROGRAM ADMINISTRATION

Vehicle Assignment Policy

Vehicles may be scheduled for use from a central motor pool on the basis of individual requirements or they may be assigned to units or departments that have major continuous needs. In those cases, equipment may be assigned to the units or departments on a continuing subpool basis. A policy should be developed that defines the conditions under which subpool assignments will be made, and such assignments should then be subject to periodic review on the basis of utilization. Emergency vehicles such as police cars and ambulances as well as specialized equipment such as four-wheel drive vehicles that must be available on demand are not subject to utilization standards in making assignments.

Utilization Standards

To ensure that the investment in a transportation fleet is held to a minimum consistent with requirements, standards for the utilization of equipment should be established. These standards can be set on the basis of a minimum level of hours of use or miles of operation per month as appropriate to the vehicle type. Utilization standards should address the vehicle's purpose, distances typically traveled in the area in which it is used, and the length of time each month during which the equipment is available. For example, utilization standards would be much higher for a vehicle that is normally assigned to long-distance trips than for one used only for short hauls between campus sites. Similarly, a police vehicle used during multiple shifts seven days a week would be subject to a higher utilization standard than one operated only during a normal forty hour work week.

Replacement Criteria

As a means of ensuring a cost-effective transportation operation, criteria should be developed for replacing vehicles before maintenance and repair costs become excessive. The criteria typically include age, accumulated mileage, and cumulative repair costs. Criteria should also set a limit on repair costs as a percentage of the replacement cost for determining whether or not to undertake major repairs. For example, replacing the major drive train components may prove more economical than replacing the entire vehicle.

8.3 USER POLICIES AND PROCEDURES

State institutions usually are required to comply with regulations applicable to all state agencies. The institution has responsibility for informing the institution's vehicle users of any regulations. Additionally, policies and regulations unique to the college or university must be promulgated along with procedures for employees who use the vehicles. The institution should publish information for the college or university community on the following:

- Travel authorization regulations and procedures.
- Driver licensing requirements.
- Authorized passengers or riders.
- Restrictions on personal use.
- Request and prioritization procedures.
- Usage rates.
- Long-term assignment policies.
- Special regulations for student use.

Additionally, the following policies and regulations are required to be publicized for all users of college and university vehicles:

- Operator care and maintenance.
- Availability and use of institutional credit card.
- Disposition of traffic violation citations.
- Procedure for vehicle pick-up and return.
- Instructions governing accidents and breakdowns.

Insurance

Insurance can be provided by commercial underwriters or by self-insurance. A variety of property damage, public liability, and personal injury coverage programs are available through underwriters. If an institution chooses self-insurance, premiums can be paid into a vehicle loss reserve account that is drawn on when needed. Over a long period of time self-insurance can be expected to be more economical. Regardless of the method adopted, insurance costs should be determined or estimated. These costs must be included when establishing vehicle rates.

8.4 VEHICLE RATE STRUCTURES

Cost Categories and Rate Computation

Rate structures are based on three categories of costs:

- Amortization of the cost of vehicles.
- Fixed costs that include insurance, equipment, salaries, and administration of the transportation system.

- Variable costs that depend upon the amount of use. These include maintenance and repair; fuels, oils, and other lubricants; tires; and repair parts and supplies.

Various kinds of rate structures are used. The one employed depends largely upon the accounting requirements of an institution. The following example presents a method for computing rates based upon all fixed costs and variable costs. This method can be adapted to virtually any other rate system.

Before computing rates, certain data need to be determined or estimated. The numbers presented are for example purposes only. The data that need to be gathered are:

- Vehicle replacement cost ($7,500).
- Expected life (5 years, i.e., 60 months).
- Residual value ($1,500).
- Estimated mileage (100,000 miles).
- Scheduling efficiency (70 percent).
- Estimated variable costs ($10,000).
- Fixed costs other than replacement ($150 per month).

Determination of Daily Rates Based on All Fixed Costs

Step 1: Determine net replacement cost by subtracting residual value from actual replacement cost ($7,500 - $1,500 = $6,000)

Step 2: Determine monthly reserve accrual required by dividing the net replacement cost by the vehicle's expected life* ($6,000 ÷ 60 months = $100)

Step 3: Add monthly fixed costs to monthly required accrual to determine total monthly fixed costs ($150 + $100 = $250)

Step 4: Determine actual days of use per year by multiplying the number of days per year times scheduling efficiency (365 × .70 = 255.5)

Step 5: To determine the daily rate, multiply monthly fixed costs by 12 months and then divide that figure by the actual days of use per year ($250 × 12 months ÷ 255.5 = $11.74)

*Group all vehicles of the same category together to obtain an average monthly reserve accrual rate per vehicle type.

Determination of Mileage Rate Based on Variable Costs

Divide total estimated variable costs by estimated total mileage of vehicle ($10,000 ÷ 100,000 miles = $0.10/mile)
The vehicle rate in this example would be $11.74 per day plus 10¢ per mile.

Van Pool Rates

Many colleges or universities have either established or supported a van pool operation in order to conserve energy, reduce pollution, reduce traffic, or provide a service to their employees. A van pool differs from other motor pool transportation in that it is designed solely to provide transportation between home and the work site. Riders are charged a monthly rate for this service, which is scaled to pay all expenses for acquiring, maintaining, and operating the vans. In some cases funds to establish the operation have been provided by the federal and/or state governments. Rates can be derived by using the systems described above for passenger vehicles. Customarily van pool riders are charged a flat rate per month that includes both fixed and variable costs.

Truck Rental Rates

Rental rates for trucks can be developed by using the same system as outlined for passenger vehicles. The scheduling efficiency for trucks will usually be lower than for passenger vehicles. Their retention period, however, will be longer. When used primarily for maintenance and construction purposes, trucks are normally charged at an hourly rate. For larger trucks, licensing requirements usually stipulate that a driver be provided. The cost of the driver should be added to the truck rental rate.

Bus Rates

Many institutions provide buses for class field trips, athletic team travel, and campus tours. In addition, buses are used to shuttle employees between remote parking lots and campuses or from main campuses to satellite facilities. Due to the high acquisition cost, driver salaries, and operating expenses, bus operations are expensive. High usage rates are therefore required to make bus operations self-supporting. However, other factors such as convenience to students or reduction of campus traffic may be of such importance that bus operations are subsidized. In these cases, break-even rates should be calculated so that the required subsidy can be considered in the decision-making process.

Bus rental rates should include a mileage charge and a time rate such as hourly, half-day, daily, and longer periods. The time rate should incorporate the driver rate, which may include overtime and per diem costs.

Heavy Equipment Rates

Since the amount of travel is a poor indicator of usage for this type of equipment, hourly rates are commonly used. The hourly rate can be determined by using the same factors as passenger vehicles with the exception that variable costs are included in the time rates. Large, expensive pieces of equipment such as cranes, bulldozers, and backhoes are normally retained for many years and therefore require long-term use projections to establish rental rates.

8.5 MAINTENANCE AND REPAIR

Vehicle maintenance and repair can be classified into three categories: driver maintenance, garage preventive maintenance, and repairs. The first two categories are both preventive maintenance, but are separated for description purposes into maintenance performed by drivers and that requiring garage mechanics.

Driver Maintenance

A clear policy should be established that directs drivers (operators) of vehicles to periodically check the condition of coolants, lubricating oil, tire pressure, and other routine items that any responsible private owner of a similar vehicle would typically check. Each time a driver signs out a fleet vehicle, he or she should be provided with a checklist of these maintenance items.

Preventive Maintenance

Transportation equipment should undergo periodic preventive maintenance inspections and service in accordance with the manufacturer's recommendations. These inspections and servicings, similar to a building preventive maintenance program, can be set up on the basis of hours of operation, mileage, or elapsed time. The preventive maintenance program should include oil change and lubrication, timely check and adjustment of the cooling system's antifreeze, engine tune-ups, repacking of wheel bearings, replacement of cooling system hoses, changing of oil and air filters, replacement of drive belts, checking and adjustment of brakes and transmission fluid, and similar measures. It is the transportation system manager's responsibility to ensure that these measures are carried out, including calling in permanently assigned vehicles when required.

Vehicle Repairs

Necessary repairs, such as replacement of parts, will normally be identified through preventive maintenance inspections or breakdowns. Where repairs are performed will depend largely upon the garage facilities at the institution and the current workload, described more fully below.

In-house Versus Contract Maintenance and Repair

When deciding whether to contract maintenance and repair or to establish a college or university garage, the size of the vehicle fleet will usually be the major consideration. Smaller institutions that own a small fleet of vehicles can seldom operate a garage economically because of the large investment in tools and equipment that it entails. Contract maintenance, full maintenance-lease programs, and servicing agreements may be more cost effective. At the other extreme, the larger institutions can normally realize greater economies by staffing and equipping a garage. However, even where campus-owned garages exist, few institutions find it cost effective to provide facilities for body work, replacement of major vehicle components, or overhauls. Since staffing and investment in tools and equipment are so extensive and the work requirements so unpredictable, it is usually more economical to take care of major repairs by contract. A final determination, however, must be made at each institution based upon the size of the vehicle fleet, comparative costs, and availability of local facilities for contracting.

Vehicle Records

A detailed operating and maintenance record should be kept for each motor vehicle. Records should provide a complete history of the maintenance and repair performed as well as their costs.

8.6 STAFFING

Staff size for transportation service varies with the size of the vehicle fleet, amount of maintenance and repair handled by the facilities department, and the measure of administrative control that is exercised over use. Small colleges may have only one person to schedule vehicles and maintain requisite records. Larger transportation organizations require mechanics, parts persons, service attendants, fuel attendants, dispatchers, billing and records clerks, and supervisory personnel. Note that leasing vehicles does not eliminate the requirements for dispatching, billing, and other administrative functions. Leased vehicles are in the custody of the college or university, but all functions relative to their use and maintenance—except as otherwise provided for in the lease agreement—are similar to those for owned vehicles.

8.7 CONCLUSION

Of all the functions that may be performed by the facilities department, none varies more in scope and methods than meeting the institution's transportation requirements. The requirements vary widely between institutions. The rates and availability of vehicles and equipment for lease or rent fluctuate depending upon location. Past practices, however, influence current methods. For example, even in cases where the purchase of a vehicle fleet and establishment of the facilities and organization for its maintenance would not be cost effective today, continuing an operation where one already exists may be the most economical alternative. Administrators need to remember that a careful evaluation of all factors must be made in each situation to determine the best method for meeting the institution's transportation requirements. This chapter cited the principal considerations for setting up the system and procedures for its operation. Appendix 8-A is attached as a sample policy and procedure guide for the use of college or university vehicles.

Appendix 8-A

Policy and Procedure Facilities Management/ Transportation Services

Use of University Vehicles for Travel on Official Business

I. References*

A. Business and Finance Bulletin (BFB) BUS-46 Use of University Vehicles

B. Letter from president, February 28, 1978, re "Use of University Vehicles"

II. Related Policies*

University Policy and Procedure Manual (PPM)
10-4 Administrative Units
365-2 University Travel Regulations—Means of Transportation
534-4.1 Vehicle Traffic Violations
534-4.3 State Pool Vehicles
534-4.5 Vehicle Accident Review Board

III. Policy

A. University vehicles shall be used only for official business.

B. Travel in university vehicles is allowed when such use is necessary to accomplish official university business and is more advantageous to the university than alternate means of transportation.

C. University vehicles are *not* to be used for personal business.

*These regulations apply to one particular university. Institutions should publish information to their community based on what is required by their state and/or institutional policy.

D. University credit cards shall *not* be used to obtain gasoline or other items for use in any vehicle not registered or leased in the name of the university.

E. Control of all general purpose university vehicles is vested in the Transportation Services department.

F. Authorized operators of university vehicles shall be limited to members of the faculty and staff or other persons on official university business who have obtained approval to use vehicles from appropriate officials of the university.

G. Each driver of a university vehicle must hold a valid operator's license and have the license in his or her possession when operating a university vehicle.

H. The driver of a university vehicle is responsible for the payment of any traffic citations incurred during the operation of the vehicle.

I. Fleet vehicles will normally be assigned on a "trip dispatch" basis in order to maximize vehicle use and minimize cost.

J. Fleet vehicles may be released to departments on a "monthly lease" basis only in those cases where it is determined to be more efficient and economical than any available alternate means of providing transportation services.

K. A university vehicle may be left at an airport only when the rental cost of the vehicle plus the parking charge is less than the cost of other feasible transportation.

L. Departmental funds are recharged at the established rates for mileage and the period of time the vehicle is checked out, including Saturdays, Sundays, and holidays.

M. Department chairs or heads of administrative units have full responsibility for the proper use and control of university vehicles released to their personnel.

IV. Procedures

A. Rental of University Vehicles on a "Trip Dispatch" Basis

1. Transportation Services will release passenger cars and trucks to faculty, staff, or other authorized persons only upon presentation of the following by the proposed driver:
   a) A valid driver's license.
   b) An **Authorization for University Vehicle Use and Mileage Report,** hereafter referred to as **Vehicle Authorization/Mileage Report,** which will provide Transportation Services with the following essential information:
      (1) Departmental budget number (4-digit).
      (2) Destination.
      (3) Date.
      (4) Estimated date of return.
      (5) Purpose and justification for trip, in detail.
      (6) Signature of driver.
      (7) Signature of approving authority.
2. Upon presentation of items l.a. and l.b. above to Transportation Services, the *dispatcher* completes the following items in the authorization section:
   a) Vehicle number.
   b) Start miles.
   c) Time out.
   d) Signature of dispatcher.
3. A copy of the **Vehicle Authorization/Mileage Report** with the above information is retained by Transportation Services, and a copy is given to the driver along with the assigned vehicle key and university credit card. This completes the "trip dispatch" vehicle checkout.

4. Upon returning the vehicle, the *driver* completes the following items in the mileage report section of the **Vehicle Authorization/Mileage Report:**
   a) Actual date of return.
   b) Time in.
   c) End mileage.
   d) Driver's signature.
5. Having completed the **Vehicle Authorization/Mileage Report,** the driver places the form in the credit card holder attached to vehicle key and returns them to the dispatcher on duty or, if after hours, places them in a location designated for vehicle key return.
6. Transportation Services enters the amount of total charges in the mileage report section of the **Vehicle Authorization/Mileage Report.** The completed form is sent to the campus computer center where the charges are entered into the computer for recharge of department funds. The computer center returns the form to Transportation Services. Transportation Services sends a copy of the form to the department for recharge reconciliation.

B. Rental of University Vehicles on "Monthly Lease" Basis
1. A department/activity requiring a university vehicle on a continuing or "monthly lease" basis submits to the superintendent of Transportation Services a completed and signed **Request for Newly Assigned Vehicle or Assignment Exchange Form.** The form is available on request from Transportation Services.
2. The **Request for Vehicle Assignment** must include—
   a) An explanation of the department's/activity's need for availability of the vehicle requested on a continuing basis.
   b) Comments about alternate means of transportation or lack of transportation.
   c) Discussion of the remoteness of department/activity operation from a Transportation Services facility.

d) Assurance that the vehicle will be used on a reasonably constant and economical basis.

3. Upon approval of the monthly lease of a vehicle, a **Conditions of Vehicle Assignment**, is prepared and signed by the superintendent of Transportation Services. The agreement is presented to the department chair or designee for signature, which completes the approval process.
4. Transportation Services, upon vehicle assignment, provides each vehicle with **Vehicle Trip Log** sheets, which must be kept in vehicles assigned on a monthly basis. The **Vehicle Trip Log** shall be maintained for each trip by each driver. No later than the 20th of each month, the **Vehicle Trip Log** shall be signed by the department chair or authorized designee and forwarded to Transportation Services.
5. Any changes in the justification of need for a vehicle on a monthly assignment must be immediately reported to the superintendent of Transportation Services.
6. Quarterly reviews of vehicle utilization are made by the superintendent of Transportation Services to assure adequate usage and economy.

V. Responsibilities

A. Department Chair

1. Authorizes use of university vehicles by departmental personnel on a "trip dispatch" or "monthly lease" basis for official university business only.
2. Acts as the approving authority for departmental vehicle use and has full responsibility for the proper use and control of vehicles released to department personnel.
3. Determines what constitutes official university business.
4. Acts as the approving authority by signing each of the following forms as required for obtaining use of university vehicles:
   a) **Vehicle Authorization/Mileage Report** (see item IV.A.1.b.).

   b) **Request for Newly Assigned Vehicle or Assignment Exchange Form** (see item IV.B.2.).
   c) **Conditions of Vehicle Assignment** (see item IV.B.3.).

5. May designate in writing person(s) within the department to function as "approving authority" in the absence of the department chair. Designee(s) shall normally be next in rank in the departmental administrative structure. Forwards copies of letters delegating this authority to the Transportation Services office.
6. Determines that use of a university vehicle is the most economical and efficient means to accomplish the required travel.
7. Arranges, to the extent possible, that persons with the same destination travel together.
8. Maintains internal security and control of blank **Vehicle Authorization/Mileage Report(s)**, available within the department.
9. Requires that the **Vehicle Trip Log**, in vehicles assigned on a monthly basis, is maintained for each trip by each driver. Ensures that no later than the 20th of each month, the log is signed by the department chair or designee and forwarded to Transportation Services.
10. Promptly informs the superintendent of Transportation Services of any suspected misuse of university vehicles or gasoline credit cards.
11. Notifies Transportation Services immediately if a previously reserved vehicle is not required.
12. Assures that any accident or citation involving a university vehicle is promptly reported to Transportation Services.
13. Assures that usage of university vehicles by department personnel complies in all respects with this policy.

B. Transportation Services Superintendent

1. Assures that pool vehicles are not released to anyone unless the vehicle has been assigned to that individual's department on a monthly basis or the driver presents a **Vehicle Authorization/Mileage Report** properly completed and duly signed as set forth in paragraph IV.A.1.
2. Ascertains that each person to whom a vehicle is released has a driver's license valid for the estimated period of vehicle use.
3. Maintains a master list of persons authorized to sign the **Vehicle Authorization/Mileage Report** as approving authority either as a department chair or designee, and checks the name of the approving authority on each tendered **Vehicle Authorization/Mileage Report** against such master list.
4. Completes that portion of the **Vehicle Authorization/Mileage Report** indicated in paragraphs IV.A.2. and 3. above.
5. Conducts periodic vehicle safety inspections, servicing, and maintenance. Keeps records and makes reports in compliance with university policies and procedures.
6. Notifies the department chair of misuse of university vehicles or credit cards. Takes appropriate action to obtain reimbursement if the department chair is unable to secure reimbursement from the driver for university costs associated with such misuse.
7. In the event the driver has failed to exercise reasonable care and control in the use/operation of a university vehicle and damage to such vehicle results, obtains reimbursement for the cost of repairing vehicle damage from the driver or recharges the appropriate department funds of the authorizing department. Personal injuries to university personnel in the course of employment are covered by Workmen's Compensation Insurance. Further, university insurance will cover personal injury or property damage to others by university vehicles whenever said vehicles are operated in the course of official university business.

C. Drivers of University Vehicle

1. Completes that portion of the **Vehicle Authorization/Mileage Report** indicated in item IV.A.1.a. before commencement of vehicle use, signs name, and obtains the signature of the driver's approving authority. Completes that portion of the **Vehicle Authorization/Mileage Report** indicated in item IV.A.4. after completion of vehicle use, signs name, and returns as indicated in item IV.A.4.
2. Must have a valid driver's license.
3. Uses the vehicle for university business only, on or off campus. Returns the vehicle to Transportation Services immediately upon completion of travel, or to the assigned location if a monthly leased vehicle.
4. Obtains all possible gasoline, repairs, parts, and service from Transportation Services.
5. Uses the credit card provided with each vehicle to purchase only regular grade gasoline or propane, oil, and emergency items necessary for the proper and safe operation of the vehicle. Credit cards may not be used for payment of parking fees or purchase of premium gasoline or accessories.
6. Promptly reports lost or stolen credit cards to Transportation Services.
7. Reports any vehicle defects or mechanical malfunctions to Transportation Services.
8. Records the appropriate data for each trip on the **Vehicle Trip Log** for monthly leased vehicles.
9. Operates the assigned university vehicle in a safe manner and within the limits of the law.
10. Personally pays any traffic or parking violations and fines, as university funds cannot be used for this purpose. Traffic violations could result in a letter of warning from the chancellor. Subsequent violations may result in temporary or permanent suspension of the privilege of driving a university vehicle.

11. In the event of an accident, obtains as much information as possible at the scene of the accident. Accident report forms and accompanying instructions are carried in the glove compartment of each vehicle. These forms must be completely filled out and delivered to Transportation Services immediately upon return to the campus.

CHAPTER 9

Key Issue and Control

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9.1 INTRODUCTION

Few facilities functions are more difficult to administer satisfactorily than building security. College and university buildings require access by large numbers of people during irregular hours and do not operate on a rigid time schedule. Ongoing research projects often demand attention to specific time intervals that do not necessarily coincide with what are considered regular working hours. In their quest for new knowledge and in preparing for teaching assignments, academicians traditionally set their own hours. In fact, many prefer night work hours and like to use their offices. Moreover, the increasing use of computers and other information-processing equipment in course work necessitates increasingly greater student access to instructional facilities outside regularly scheduled hours. Meeting these requirements while providing necessary building security becomes difficult. It calls for close coordination between facilities use and building security. Much revolves around the locking and unlocking of buildings and key issue and control.

Plant departments normally have responsibilities regarding building security although the specific roles vary widely. At some institutions they have nearly complete responsibility for coordinating all security matters including employing security forces. At the other extreme, they perform only the mechanics of key fabrication, issue, and recovery. It is not appropriate or even possible to describe recommended functions and systems in this chapter. Instead, underlying principles and considerations will be discussed in conjunction with the advantages and disadvantages of certain methods that can be used to design or improve systems and procedures to meet the specific needs of each institution.

9.2 CAMPUS KEYING SYSTEMS

Most colleges and universities have an integrated campus-wide keying system for all buildings in which all locks are coded and combinated as components of the total system. What follows are the types of keying of locks in an integrated system.

Campus Master or Grand Master Key The campus master key, sometimes referred to as the grand master, will operate any lock on the system. A campus may have more than one such campus master key, each independent of the others. This arrangement usually stems from a decision to adopt a new keying system without simultaneously converting all buildings to the new system.

Building Master Key A building master key will operate all locks on the building system, including exterior doors.

Submaster or Area Master Key Functional areas of a building may be keyed so that each lock is keyed separately but in a way that permits a single submaster or area master key to open all locks on the subsystem.

Interior Door Keys that Open Only the Single Lock for Which They Are Issued Two or more locks may be keyed alike and consequently can be operated by the one key. Locks keyed alike are not the same as submaster systems.

Exterior Door Keys that Unlock Outside Building Doors Normally, all exterior doors are keyed alike. There are exceptions such as a building with separate entrances to different functional areas such as academic departments. Typically, all exterior door keys are on the building master system and may be on one or more submasters.

Locks Keyed Separately from the Building Master System Certain locks in a building may be taken off the building master system. This restricted access is normally due to either safety requirements or to the absence of a need for access by building occupants.

Presented below are the most common separately keyed areas.

- Transformer vaults. Where transformers for stepping down high voltages to utilization voltages are located in buildings, they are installed in vaults keyed separately from the building system. All transformer vaults on the campus can be keyed alike so that maintenance personnel have convenient access to them.
- Mechanical rooms. All mechanical rooms on the campus may be keyed alike, separate from the buildings systems. Only plant personnel, or personnel of contracting firms who are performing work in the building, normally require access to them.
- Custodial rooms. Custodial rooms or closets usually contain a sink and water supply plus storage facilities for custodial equipment and supplies. Like transformer and mechanical rooms, they can be keyed alike throughout the campus though separate from any building system.

- Temporary construction areas. During alteration projects, additions to buildings, and larger repair projects undertaken by either the plant department or contractor, it is often desirable to secure construction materials, tools, and equipment. Contractors often have their own construction lock cores. The plant department can also set up construction lock cores that are keyed separately from any building system. They can be installed in locks to rooms that have been set aside for the duration of the projects as secure storage areas. Care must be taken not to block building emergency exits.
- Special security areas. Individual rooms that require high security may be keyed off the building master system. This should be avoided if possible since it requires coding equivalent to that of a new building.

Whether keying a new building or rekeying an existing one, a building keying plan should be developed. Primary input comes from the building occupants. The plan is used to support the building's functional use. It describes the keying desired for each lock—including those rooms that are to be keyed alike, those rooms that are to be keyed separately from the building master system, and groupings of rooms on submaster systems. Few, if any, colleges or universities have the means for developing codes to meet the keying plan. Consequently, this is normally handled by a single lock company that maintains keying records for the entire campus. All locks are coded to conform with the keying plan and ensure that no code is duplicated. In the event that there are different kinds of locks on the campus, adaptors can be used for conversion to the selected make of lock core. The plant department normally holds responsibility for maintaining keying code records for all the locks on campus.

The building keying system pertains only to room door locks of a building. It excludes storage cabinets, lockers, and drawers in individual rooms. In addition, residence halls are not normally included in a campus key issue and control system. The plant department may furnish residence hall keys upon request or it may perform lock installation, repair, and replacement. However, the responsibility for issuance, control, and return of residence hall keys rests with the facility's director.

9.3 KEY ISSUE AND CONTROL GUIDELINES

Some guiding principles can be used to set up or maintain a viable key issue and control program on campuses. Presented below are underlying principles for implementing workable and responsive procedures.

Provision should be made for access, separate from the key issue system, to common-use facilities for scheduled activities. Similarly, a plan should be devised for all doors to be locked beyond regularly scheduled hours. Otherwise it may be necessary to issue keys to everyone who may potentially be the first user of each facility each day.

Locks on doors should be self-locking. That is, they should not require a key to close them. If this policy is not maintained, it becomes necessary to issue keys to each individual who might remain in a building past normal working hours. At that point, responsibility for locking the building cannot be fixed.

The building keying system should not be relied upon for the security of valuable materials and equipment or items that can be pilfered. Rather vaults, cabinets, lockers, and similar facilities with special locks can be used to meet special security requirements while permitting access for assigned functional use.

Issuing keys to individuals should be based on access needs rather than position. Normally, officials such as deans and department heads are issued keys to all facilities in their charge if they choose, but keys should not be automatically issued without verifying the need. Many officials simply want access to their own offices beyond regular hours.

Keys should be issued permanently only when the need for frequent access outside regular hours can be foreseen. Cutting down on permanent issues can often be done by establishing a system for temporary loan for occasional anticipated situations or for gaining access via the campus police or other security organization when the need is not anticipated. The same principle should guide the issuance of various levels of keys: building master keys should not be issued for occasional access to areas if normal requirements can be met by the issue of several keys.

Convenience of access to, and security of, the buildings are in direct opposition. Convenience of access, as a result, must be sacrificed in proportion to the degree of security achieved.

No key control system can be effective unless there is compliance and unless the system is the sole source of keys to the institution's buildings. Commercial facilities for duplicating keys are readily available in most parts of the country, and any violation of laws or regulations regarding duplication of keys is committed by the individual requesting the copy rather than the duplicating agency. Employees can often have a college or university key duplicated outside at nominal cost and more conveniently than can be done through the institution's system. Occasionally, departing faculty and staff members pass their keys along to their replacements. Unless such practices are prevented by the college or university administration, building security will be compromised, regardless of the effort spent on a campus key control system.

Because large numbers of keys are on issue at any one time and rekeying of locks on a campus-wide system calls for recoding to conform with the system, making changes in either the key issue records system or the keying system is time-consuming and costly. Additionally, it inconveniences many people. It is, therefore, important to protect building keying systems from compromise and to have key issue and recovery systems that are planned, workable, and well-enforced so as to be long-lasting.

Administrators need to remember that obtaining keys to work spaces is essential to getting work done. Obtaining a key to a work space is not a privilege, such as securing a locker in a recreational facility. Issue systems that require excessive time and effort on the part of the applicant or cause undue delays can interfere with the institution's work.

9.4 ANATOMY OF A KEY CONTROL SYSTEM

There are many kinds of key control systems in use at colleges and universities around the country. Which system to choose will depend upon many factors including the breadth of facilities, size of faculty and staff, building use schedules, value of instructional and research equipment located in campus buildings, size and duties of security forces, and the degree of security desired. However, the administration of any viable system calls for the following action:

- Assign key issue authority.
- Assign key recovery responsibility.
- Establish procedures for expeditious issue and recovery.
- Maintain up-to-date functional records of issues.
- Assign funding responsibility for building lock and key systems.

Key Issue Authority

Authorization for key issues consist of some combination of a campus policy for issues to individuals and recommendation for issuance from an individual's department or division. If the policy is definitive regarding issuance criteria, little further action is required beyond verifying that the individual meets the criteria. However, if the policy is a general guideline—key issuance will be "based on need for access"—it is then necessary for a department official who is familiar with the work requirements of the individuals concerned to have primary authorization powers.

It is generally accepted policy that no college or university official should authorize the issue of keys to spaces other than those occupied by the organization for which he or she has responsibility. For example, the head of an organization to which a total building is assigned would have issue authority up to and including the building master key. Where two or more departments occupy one building, each may authorize key issues to their assigned areas. However, the issue of master keys to the building could be authorized only by the common superior unless coordination authority were specifically assigned to one party. The issue authority may, of course, be restricted by college or university policy.

Key Recovery Responsibility

The campus policy must prescribe the length of time for which keys may be issued plus the conditions for their return. The return policy is usually set up in the following fashion:

Permanent employees shall return keys—

- Upon termination of employment or transfer to another organization.
- Upon being granted a leave of absence. A leave is defined as absence from the campus for a specified period such as 30 days or more.
- Upon request of the issuing authority.

Temporary employees and students shall surrender keys—

- At the end of the semester or period if the student will not need the keys for at least a specified period such as 30 days. The intent is to prevent keys from being kept over summer breaks or during other regular school sessions for which the individual is not enrolled or employed at the institution.
- Upon request of the issuing authority.

Since only the department or administrative heads know the status of individuals in these categories, they usually hold responsibility for the return of keys. If recovery responsibility is assigned in another way, there must be close coordination with the department and administrative heads for the timely recovery of keys.

Key Issue and Recovery Procedures

If undue time and effort are required to obtain a key, it can cause obstacles to compliance. In fact, complicated procedures can cause violations that virtually void the system in a short time.

Unfortunately, the process for obtaining keys often shows bureaucracy at its worst. For instance, it is not unusual for a key requester to be required to complete forms, go to several different offices for approval of the issuance, and make a deposit, and then proceed to a key shop located on the outskirts of the campus only to have to complete the process in reverse to return a key and claim his or her deposit.

The simpler and more convenient these procedures can be for the key requester, the more effective and inviolable the functioning of the issue and recovery system will be.

The minimum functions that are essential to key issue/recovery and the maintenance of appropriate transaction records are presented below.

Issuances—

- Completion of a form by the prospective recipient. The form calls for information on the individual's employment status, department affiliation, and access required.
- Issue approval signature.
- Payment of a key deposit, if required, and verification of the deposit.
- Notification to the campus key shop of the specific access or keys required.
- Fabrication of the keys and marking them with an identification number. This number should be coded so that in case of loss the finder will not readily be able to identify the space to which access can be gained. Recommended coding is a building number and the last one or two digits of the room number.
- Entry of above key information on the issue form.
- Delivery of the key to the recipient and securing of a receipt signature.
- Entry of the issue date and record of transaction into the records system.

Recoveries—

- Return of key, ultimately to the key shop.
- Refund of cash deposit if appropriate.
- Removal of issue records from the records system.

As many as possible of these functions should be handled by administrative personnel with minimum inconvenience to key recipients. In fact, routine issues can often be handled almost entirely in the department office. There the requester completes the request form and submits a cash deposit if one is required. The next step takes place via mail or hand delivery. The only other step the requester must take is to pick up and sign for the key at the department office. The same procedure is followed to turn in the key. All business is transacted by the keyholder at the department office. Appendix 9-A describes such a system. In the case of issuance, the requester should have the option of hand carrying the documents through the system to expedite the process.

Recordkeeping Principles

Keeping good records of key issues will promote the smooth functioning of the control system. Simply filing a copy of an issue form once a key is issued and then removing it when the key is returned is of little value. To be useful for retaining control and for serving departmental security needs, key issuance records should be kept with these needs in mind:

- A list of all keys that are on issue to persons affiliated with a department or administrative unit should periodically be provided to each department or administrative head for verification of accuracy, for correcting, or for reporting discrepancies.
- Prior to the impending key recovery date, a list should be drawn up of all keys that are due to be surrendered. Lists of all keys, temporary or permanent, should routinely be furnished just before the end of the semester.
- On request, a list of all keys on issue to a specific person should be furnished.
- The name of the individual to whom a key with a specific serial number is charged out is strictly confidential. Only upon request of an institutionally recognized and approved authority should the name be provided.
- On request, all individuals to whom keys that grant access to a specific space have been issued should be identified.

These kinds of records may be maintained by each academic department/administrative unit or by the plant department. In the past, a centralized system maintained by the plant department has been used because it could be administered effectively and most efficiently. However, as better college and university information systems are developed and become available to all campus entities, the advantages of a centralized records system diminish.

Regardless of where the responsibility for records is assigned, certain information should be recorded for each key issuance. The vital data are—

- Name, institutional status, and organization of the requester.
- Office and name of person authorizing issue.
- Type of key issued (such as master, submaster, room key) and building.
- Key identification number.
- Type of issue. This may be permanent or temporary. If temporary, the date to be recovered should be recorded.
- Date of issue.

No matter where the records are maintained, good practice dictates periodic campus-wide verifications of record accuracy and regular correction or elimination of erroneous or outdated information. Verifications and updates should be undertaken at least annually, and, at a minimum, should confirm that the status of persons to whom keys are charged out remains the same as what is shown on the records. This procedure allows for corrective action to be taken in some cases. An example would be the recovery of keys from personnel who have departed from the institution without complying with return requirements. The procedure also helps administrators evaluate the state of building security and may pinpoint areas in the key issue and recovery procedures that need improvement.

Recordkeeping Techniques

There are various methods, both manual and computerized, for storing and retrieving information about keys. The volume and variety of information to be recorded and the processes that may be required to retrieve the information in the form that is needed—particularly at large universities—recommends machine storage and processing. If an institution is currently using a good manual system, it is easy to computerize. If, however, an institution is working with a hand-kept system that is not methodical, orderly, or easily understood. starting out anew with a computerized data base is an option to consider.

One of the capabilities of a computerized system that recommends its use is its capacity for extensive cross-referencing. For example, keys can be searched and identified by building name, room number, key number, employee name, or even authorization. Another advantage is the speed with which information can be retrieved. Yet a third attraction is the ease of updating records on an automated system. The typical hardware for a computerized system consists of a monitor (video screen), a terminal with a typewriter-like keyboard, and a printer that types out information on paper. Information can be called up either on the monitor or printed as hard copy. Printing is most useful for reports to other departments.

Funding Responsibilities

The authority over building locking and keying systems and key control is often divided. Therefore, campus policies must recognize funding responsibilities. Generally, whichever institutional entity exercises authority over administration of keys bears fiscal responsibility for key control matters. Just how funding responsibilities are divided on campuses according to this principle, however, is described below.

Routine maintenance and repair of locks and lock cores, which includes replacement of malfunctioning parts, is part of comprehensive upkeep of facilities and is, therefore, the funding responsibility of the plant department.

The keying of a new building, which includes purchase and combinating of lock cores, is typically part of the construction cost and is included in the project funding.

Financial responsibility for rekeying of a building, which includes the purchase and/or the recombinating of lock cores along with complete new key issues, will vary, depending upon the reason for rekeying. If the department that occupies the building holds authority and responsibility for key issue and recovery, and if building security has been compromised by excessive issuances and failure to recover keys, funding responsibility would normally rest with the department. However, if rekeying is brought about by factors beyond the control of the department—such as reassignment of facilities or the need to update an antiquated keying system—funding would normally be assumed by the plant department.

The routine issuance of keys, which depends upon faculty and staff turnover, can generally be predicted. However, a department generally has little or no control over it. Consequently, this task is usually best handled by the plant department.

Compliance Strategies

The key control policies and procedures are designed to strike a desired balance between building security and facilities use. Noncompliance with these policies, however, compromises security and may necessitate stringent controls that may create inconveniences, if not actual barriers, to functional use.

The three most prevalent violations by individuals are obtaining keys outside the college or university system, failing to return keys, and losing keys because of a failure to properly safeguard them. What follows are measures that may be taken in order to give emphasis to, or require compliance with, key issuance policies and procedures.

Cash Deposit Requiring a cash deposit that is refundable upon the return of the key often is helpful in accomplishing key recovery. However, most cash deposits of any kind are based upon intrinsic value. In order to influence recovery significantly, deposit sums would have to be much higher amounts than the cost of fabrication. This may, in turn, cause resentment and lack of cooperation. In addition, deposits sometimes imply that a key has been purchased, and from there the individual can assume he or she has the right to forfeit the deposit. This may lead to resale or passing the key along to a successor for all or part of the deposit. The administration of a key deposit system requires considerable administrative work and complicates the issue and recovery procedures.

Withholding Final Pay or Academic Transcripts Holding back the final pay of departing employees and transcripts of departing students are strong measures that are certain to achieve a high degree of compliance if they are strictly and uniformly enforced. The legal and public relations aspects, however, should be carefully considered, particularly in cases where enforcement can result in personal loss. An example would be a case where a graduate may be eliminated from consideration for employment because of the withholding of a transcript. Similarly, this policy may cost a departing employee hundreds or even thousands of dollars in withheld salary.

Fines In lieu of a refundable deposit, fines may be levied for failure to return keys. In order for a policy such as this to work, the fine system must be common knowledge and enforcement must be credible. Enforcement may require additional measures such as those described in the paragraph above.

The most successful college and university key control systems are those in which personnel are informed of the policies and procedures as well as their purposes, those in which key issues and returns are made as convenient as possible, and those in which an attitude of cooperation by all concerned parties prevails. In short, every effort is made to meet the needs of faculty, staff, and students while maintaining the required level of security.

9.5 KEY FABRICATION AND LOCK TYPES

Key fabrication requirements can be met by a key coding machine that cuts keys to codes and a key duplicating machine. Most colleges and universities have this total capability. Some possess only the key duplicating machine, which means that one key of each type must be purchased whenever a building, or any portion of a building, is rekeyed. It is, of course, possible to rely entirely on commercial fabrication facilities where available. The method chosen depends upon comparative costs and convenience to personnel, which, in turn, depends largely upon an institution's volume of issues.

Hardware must be matched to special institutional needs. Some fundamentals about locks related directly to unique campus demands are presented below.

The key mechanism of a lock is separate from the lock itself. The part of the mechanism operated by the key contains a tongue that projects into the lock. It contains up to seven pins, each of which can be set for up to ten different positions. The coding sets the position of each pin for unlocking as well as the depth of each notch in the key. The key then raises each pin to the proper height to permit turning the cylinder, the part operated by the key, which activates the lock by means of the tongue that connects with the lock. With a 7-pin set, 78,125 separate key combinations are possible.

There are three basic types of locks:

- Cylindrical lock, or key-in knob. The key mechanism is contained in the knob.
- Rim lock. An exterior metal case is mounted on the interior surface of the door.
- Mortise lock. The lock is set into a mortise or cavity that is cut into the door.

Mortise and rim locks can be further classified as spring latch or deadbolt. The spring latch can be locked by releasing a thumb latch, while the deadbolt requires a key for locking or unlocking. An advantage to deadbolts is that they cannot be locked inadvertently. Deadbolts are used frequently for residence hall rooms and private offices. However, they cannot be used—except with panic exit devices—on exterior doors or on any door in a building's emergency escape route.

For doors that must afford access to the handicapped, the most satisfactory locks are electrically operated. They are designed so that the electric circuits are deactivated upon locking the door and activated upon unlocking. In entrances that require handicapped access but where electrically operated locks are unavailable, lever handles are preferable. They are especially suited to emergency doors where turning a knob would obstruct a quick exit. For example, lever handles are appropriate for a chemistry laboratory in which the occupant's hands may be burned or covered with a chemical as a result of a fire or chemical spill. Lever handles and foam rubber covers are available for attachment to round knobs.

9.6 SPECIAL LOCKING SYSTEMS

Certain areas on a campus require greater security than standard building locking and key control systems can provide. Those are storage areas for flammable or toxic chemicals, areas where radiological materials are kept, and areas that house valuable equipment. Currently there is a variety of high-security locking equipment on the market and periodically new and better equipment is introduced.

The equipment falls into three general categories: locks with specially shaped keys that are difficult to duplicate, combination locks that require knowledge of a code or use of a card reader that is coded for the specific lock, and electrically operated locks that either operate on a time schedule or are actuated from a remote location. All of them work on the principles of being relatively tamper-proof and of strictly safeguarding access to the unlocking information or equipment. These devices usually are independent of the building locking and key control system and are controlled by the director of the facility in which they are used. The plant department may be assigned responsibility for the secure storage of combinations or duplicate opening devices, but special regulations must be promulgated regarding access.

Presented below are brief descriptions of only three types of the many special locking systems that are available. One variety employs different styles and shapes of keys—such as the triangular key with a dimple—that makes it difficult or impossible for the campus or local locksmith to duplicate. Some of these keys must be ordered directly from the factory. Since they cannot be made by a locksmith, tighter control can be exerted over the keys but service becomes more difficult.

The second type of device is a pushbutton combination lock. Some are mechanical while others are electronic. They operate by pushing a series of buttons in a given sequence to open a door. They are useful in situations where there is an outside door to a restricted area from which the general public must be barred.

Several types of combination locks are on the market in which a computer can automatically be programmed to change the combination at set times. Some devices have a detection feature that can indicate an alarm condition when someone who does not know the correct combination tries the buttons.

A card reader lock is another form of "nonkey" system that helps restrict entry and exit to an area. The device is really not a lock at all, but rather a method of operating an electric strike. With this system a card is inserted in a machine that reads a special identification code, which then opens up a specified lock. Some systems record who the person is that is opening a particular door and when they gained entry.

9.7 ACCESS FOR PHYSICAL PLANT WORK REQUIREMENTS

One of the most difficult problems to deal with in the realm of key control is how to provide access to buildings for plant work.

With many major campuses containing more than 100 buildings, it is not unusual to have between 100 to 200 skilled workers engaged in maintenance and repair work. What the situation demands is numerous simultaneous key issuances and recoveries. It is impossible for one issuing agency to handle all the key issuances and returns that workers require.

Other unique considerations regarding access of plant personnel must be taken into account. They are—

- Access to different parts of the same building may be required by two or more workers engaged in unrelated work.
- Regardless of whether workers are operating on a salaried or charge-back system, the time spent in gaining access is costly. For example, if 100 workers each spend a total of 15 minutes a day to obtain keys or otherwise gain access to work locations throughout the campus, there would be 15 workhours lost time. Therefore, whatever system is used should be efficient and highly responsive to needs.
- Each worker may require access to spaces in several buildings in the course of a day.
- Much of the work of a plant department is decentralized with a minimum of prior planning. For example, a worker sent to correct a problem may not know in advance the specific rooms that will require access.
- It is desirable that individual workers not be charged with, or keep permanently in their possession, keys to all facilities to which access may be required by their work assignments.

Meeting these conditions and requirements is difficult, particularly on a large campus. Three general methods are used.

The first is a system in which each shop has several rings of master keys for the entire campus or for major subdivisions of the campus. These are kept in a locked cabinet in the shop with each ring marked for easy identification. All workers in the shop have easy access to the rings during working hours. The shop supervisor or other assigned person has responsibility for assuring that all key rings are returned at the end of working hours and that the case is locked. Arrangements must be made to gain access to buildings for emergency work that takes place outside regular hours. This can be handled by arranging for a security force to provide access either to the work site or to the key cabinet in the appropriate shop.

A second system uses a sequence lock in each building. A sequence lock is a rim-type lock that contains two interchangeable cores that operate in conjunction with each other. One of the cores is combinated for the building master key, while the other is combinated for the access key. The building master key is trapped in the core. When used to release the master key, the access key is trapped. Workers, therefore, can be issued indexed access keys with which they can obtain master keys to buildings. But to obtain a master key, their access key remains in the lock so that the holder can be identified. The access key cores can be changed when a key is lost or changed periodically to maintain a higher degree of security. To meet maximum work requirements, an adequate number of master keys should be available in each building.

The disadvantages of a sequence lock system are threefold. First, the access keys must either be retained permanently by the individuals to whom they are issued or else another system must be designed for the secure storage of the access keys outside regular working hours. Second, with such a dispersal of master keys, the early detection of a missing master key can be difficult. Finally, separate provision must be made for obtaining admittance to the building to gain access to the master keys.

The third method, a variation on the "locked cabinet" system, is often used for custodians. A locked box that contains rings of submaster and individual room keys or of individual master keys is located in one of the custodial closets. At the beginning of the work day, the supervisor unlocks the key box and furnishes key rings to custodians for their particular work assignments. At the end of working hours, all key rings are returned and locked in the key box.

9.8 CONCLUSION

This chapter has aimed to present practical information to help the plant administrator maintain a balance between building security and facilities use. A good key control program attempts to promote wide access to instructional facilities, restricted but round-the-clock access to research laboratories, and a responsive reaction to faculty needs. It must also successfully address access for plant work requirements.

For administrators to offer flexibility to institutional users means devising basic but workable key issue and recovery systems. (A sample policy is presented in Appendix 9-A). Central to that task is developing strategies that promote convenience for key requesters while instilling healthy respect for compliance. Guarding against wanton key copying, nonreturn of keys, or careless handling of keys are but a few of the challenges. By developing sound policies and abiding by some guiding principles, administrators can successfully maintain a crucial balance between building security and facilities utilization.

Appendix 9-A

Property and Capital Equipment Policy
Keys to University Buildings

A. Policy

1. It is the policy of the university that other than during normal working hours, all buildings shall be locked in order to maintain the security of both the buildings and their contents.
2. Staff members and students may be issued keys to university buildings upon the recommendation of the department chair or administrative head and approval of the official in charge of the building, or his/her designee, in accordance with established procedures.
   a) Keys are issued for entry to university buildings for the purpose of conducting university business only.
   b) An authorized individual entering or leaving a locked building shall not permit any individual to enter who would not normally be permitted to enter the building during the hours it is locked. An authorized individual may have guests so long as the guests stay in the proximity of the faculty or staff member having the assigned key and the authorized individual assumes full responsibility for their presence.
   c) An individual entering or leaving a locked building shall be responsible for securing the door and may be held responsible for any loss or damage to university property resulting from failure to do so.
3. Special assignment of keys, where required, (such as to contractors, etc.) may be authorized by the campus business officer (director of physical plant).
4. All keys issued remain the property of the university and shall be returned under the following conditions:
   a) For staff members:
      (1) Upon transfer to another department or building.
      (2) Upon termination of employment.

    (3) Upon the request of the department chair or administrative head.
    (4) Upon being granted a leave of absence without pay for a period of 30 or more calendar days; however, staff members granted such leaves may retain their key *if* they are authorized to have access to the building and/or office during the leave.
  b) For students:
    (1) At the end of the academic semester or period after which the keys will not be used for at least 30 calendar days.
    (2) Upon the request of the department chairperson or administrative head.

5. Individuals transferring to another department or building may be issued new keys upon the recommendation of the new department chairperson or administrative head and approval as defined in paragraph 2 above.

6. It is the responsibility of the appropriate department chair or administrative head and official in charge of the building or his/her designee, to ensure that all keys are returned under provisions of paragraph 4 above.

7. In no case is a key to be transferred from one individual to another or to be obtained from any source other than from the university. When any transfer or duplication of a key is made or used without university consent, the key shall be recovered and the individual(s) involved reported to the administrative head, dean, or superior officer for appropriate action.

8. Each campus shall be responsible for the establishment and implementation of regulations and procedures necessary for the assignment and control of keys to university buildings. All such regulations and procedures are subject to the review and approval by the Office of the Vice President for Business Management.

B. Regulations

1. Keys to cabinets, lockers, and drawers within buildings or to dormitory rooms are not covered under provisions of this policy. Physical plant will furnish such keys upon request, but the issue, control, and recovery of these keys are the responsibility of the director of the facility.

2. Key issuances are authorized by the department chair, subject to such policy guidance as may be issued by the divisional dean and instructions of the building coordinator.

3. The types and number of keys issued will be limited to the minimum required by regular work assignments.
   a) The permanent issuance of building master keys will be limited to those persons needing frequent access to most of the building, normally department chairs or higher.
   b) Two or more keys may be issued to those requiring access to several rooms throughout the entire building.

4. Procedures for the issuance and return of keys may be altered by the superintendent of physical plant to make keys available to plant personnel as required to meet work requirements throughout the campus.

5. The loss or theft of any key is to be reported immediately to the department chair, who in turn will notify the key shop, physical plant.

6. Lost keys turned in to a department are to be forwarded immediately to physical plant.

7. Applications for keys are made on a *Key Record* (University Form 1).
   a) *Key Record* forms must be typed and must be submitted with all carbons and copies intact.
   b) A separate form is used for each key requested.
   c) *Key Record* forms are available from the storeroom.

8. As standard procedure, physical plant will deliver and pick up keys at the department.

a) Keys may be obtained directly from physical plant by presenting an approved *Key Record* at the key shop, physical plant, general services building between the hours of 8:00-9:00 a.m. and 1:00-2:00 p.m. daily.

b) The department is responsible for contacting physical plant and making the necessary arrangements to have returned keys picked up.

9. Prior to the end of each academic semester, each department will be provided with a list of individuals assigned keys to areas under its jurisdiction.

   NOTE: These lists will aid the department in identifying those keys to be returned by students or staff having an ending date of appointment as of the end of the semester.

10. Annually, each department must check and certify the accuracy of an inventory list of keys issued for areas under its jurisdiction.

11. Keys must be presented at the request of any watchman, campus police officer, or other law enforcement official in the performance of his/her duty.

12. Facilities located outside the city limits should contact the physical plant department for any special procedures required by their location.

C. Procedures: Issuance of Keys

Department	1. Upon request for key, initiate *Key Record* (University Form 1), completing Items No. 1-8. NOTE: Keys assigned to students (Item No. 3) are temporary assignments (Item No. 4), and *all* temporary assignments (Item No. 4), require entry of a date that key is due to be returned.

	2. Approve *Key Record* (Item No. 9).
	3. Obtain building coordinator's approval if applicable (Item No. 10) and send form intact to physical plant.
Physical Plant	4. Produce key, and deliver key and copies 1-4 of *Key Record* to department.
Department	5-A. If Applicant Is Available: a) Obtain applicant's signature on *Key Record* (Item No. 12). b) Give key and copy 4 to applicant. c) Give copies 1 and 3 to physical plant representative. d) Retain second copy and file in alphabetical sequence or in individual's personnel file as reference to whom keys are issued.
	5-B. If Applicant Is Not Available: a) Sign *Key Record* (Item No. 11) and give copy 3 to physical plant representative, retaining copies 1, 2, and 4 intact. b) When applicant is available, obtain signature on *Key Record* (Item No. 12). c) Give key and copy 4 to applicant. d) Send copy 1 to physical plant. e) Retain second copy and file in alphabetical sequence or in individual's personnel file as reference to whom keys are issued.

D. Procedures: Returning Keys

Department

1. Upon determining that an individual is transferring or terminating employment with the university, review files to see what keys are to be returned.
2. Retrieve key from individual, making certain that key number matches that on copy 2 of *Key Record.*
3. Signify receipt of key by signature on copy 2 of *Key Record* (Item No. 13).
4. Notify physical plant of key to be picked up.
5. Surrender key to physical plant representative and retain receipted copy 2 of *Key Record* until deletion of issue record is verified by next report, after which time copy 2 is destroyed.

E. Procedures: Lost, Stolen, or Recovered Keys

Department

1. Notify physical plant immediately by telephone when a key is reported lost or stolen.
   NOTE: Replacement keys are requested in accordance with above procedures.
2. Pull copy 2 of appropriate *Key Record* from file.
3. Enter "Lost" or "Stolen" in Item No. 13, then sign and date *Key Record.*
4. Forward copy 2 to physical plant.
5. Notify physical plant immediately by telephone when a key is recovered.

Sample Key Record

PHYSICAL PLANT USE ONLY

KEY NUMBER	DATE ISSUED	
TYPE KEY	BLDG CODE	DEPT CODE

1. APPLICANT'S NAME (LAST, FIRST, MIDDLE INITIAL)

2. FEDERAL I.D. NUMBER

STATUS OF APPLICANT ☐ FACULTY ☐ STAFF ☐ STUDENT

4. TYPE OF ISSUANCE ☐ PERM. ☐ TEMP.

DATE DUE

5. TYPE KEY (RM NO.) ENTRANCE—SM NO.

6. BUILDING

7. DEPARTMENT

8. DEL. KEY TO RM. No.________

BUILDING

9. APPROVED—TYPED OR PRINTED NAME & SIGNATURE OF DEPARTMENT CHAIR

10. TYPED OR PRINTED NAME & SIGNATURE OF ADDITIONAL AUTHORITY (AS REQUIRED)

11. SIGNATURE OF INDIVIDUAL RECEIVING KEY (IF NOT APPLICANT) DATE

12. SIGNATURE OF APPLICANT *(I certify that I have received this key described hereon, and that I have read & agree to the conditions of issuance as stipulated on the reverse side of this form.)* DATE

13. KEY RETURNED (SIGNATURE OF DEPT. CHAIR & DATE)

14. KEY RETURNED (SIGNATURE OF KEY SHOP REP & DATE)

KEY RECORD

1. Physical Plant **3. Physical Plant**
2. Department **4. Employee**

CHAPTER 10

Environmental Health and Safety

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10.1 INTRODUCTION

One of the principal factors to shape both the condition and operating costs of institutional facilities during the past 40 years has been the growing concern for public welfare. Within the broad area of public welfare no aspect has received more attention or been the subject of more government mandates than public health and safety. Many factors have contributed to this increased concern and emphasis. The disastrous Coconut Grove fire in Boston in 1942 as well as several tragic hotel fires in the late 1940s pointed up the need for more stringent building codes and standards in addition to strict enforcement. The harmful effects of numerous hazardous materials, particularly chemical and radiological substances, were unknown until comparatively recent times. Development of new chemical materials added to the problem. Population growth in the United States and its concentration in urban areas made it more important, and at the same time more difficult, to maintain a healthy and safe environment.

In the sphere of public health and safety, the primary concerns of a college or university are in two areas: building codes and standards that pertain principally to structural safety and fire protection, and the management of hazardous materials. Hazardous materials are defined as those substances that are toxic, corrosive, reactive, infectious, flammable, carcinogenic, or mutogenic. Colleges and universities have a legal responsibility to comply with government regulations that pertain to health and safety. They also have a moral obligation to keep up to date on the growing information on health and safety matters and to take prudent actions for the protection of the institution's community regardless of the existence of specific regulations.

A program to carry out an institution's legal and moral responsibilities in health and safety must encompass all aspects of campus life—teaching, research, athletics, recreation, residential, and industrial. However, this far transcends the normal role and capabilities of a facilities management department. In fact, environmental health and safety has become so broad in scope and technical in analysis and application that most colleges and universities have established a separate office for handling these matters. If the facilities management department is assigned the function, it must be furnished a capability for carrying out those responsibilities—which it does not normally possess. Therefore, this chapter is limited to general policy and organizational considerations and to the environmental health and safety responsibilities that typically fall to the facilities management department by virtue of its assigned mission and functions.

10.2 POLICIES

A firm requirement for any institution is to establish an environmental health and safety program by adopting a policy statement. The statement mandates the creation of a program for the protection of the health and safety of the college or university faculty, staff, students, and visitors. The policy must designate an official agency of the institution to be responsible for administering health and safety, including initiating and enforcing the rules and regulations that may be required to meet the desired objectives. The agency's title may vary. A 1981 survey conducted by the National Environmental Health Association of 101 institutions with enrollments of 15,000 or more revealed that 17 different titles were used for departments relating to environmental health and safety. The three most frequently used titles were Department of Environmental Health and Safety, Department of Radiation Safety, and Department of Campus Safety.

Where this office is positioned in the administrative structure varies from institution to institution. Some offices charged with environmental health and safety responsibilities report directly to the chancellor or president, while others report to a vice-chancellor or vice-president. At some institutions the agency is accountable to the director of student health services. In addition, there are cases where the agency reports to the facilities management director. Most often the director of the agency has a status equal to that of the facilities manager and they report to the same official.

Even though the facilities management department does not have primary responsibility for all of the institution's health and safety matters, it is accountable for carrying out those aspects of a health and safety program that fall within its jurisdiction. These include—

- Maintenance of safety-related facilities such as fire alarms and fire suppression systems.
- Prevention of accidental injury and occupational sickness in the execution of facilities management work.
- Management and proper disposal of hazardous materials generated or used by the facilities management department.
- Ensuring compliance with building codes and standards in the design and execution of repair, alteration, and new construction projects. See Part V, Chapter 3, "Design Phase."

To carry out the department's daily responsibilities facilities managers must adopt a policy statement that encompasses the institutions' policy yet clearly establishes their own departmental program.

10.3 ADMINISTRATIVE ORGANIZATION

A college or university organizational plan for health and safety should promote decentralization of responsibility to the most competent level capable of delivering specific services directly to campus personnel. Consequently, the administrative head of each department, agency, organizational division, or program has the primary responsibility for assuring that the people under his or her jurisdiction work in an accident-free climate and observe safe practices. For this reason a Campus Environmental Health and Safety Committee, composed of faculty, staff, and students and which acts in an advisory capacity in matters of program guidance and policy approval, can be an invaluable tool in securing campus-wide cooperation for an effective program.

The major responsibility for carrying out and enforcing the policy naturally rests with the Office of Environmental Health and Safety, whose director is usually an exofficio member of the Campus Environmental Health and Safety Committee. The director provides administrative support, advice, and guidance to the committee. Depending on the size of the institution and the complexity of its activities, an Office of Environmental Health and Safety may include personnel trained in sanitation, radiation safety, industrial hygiene, and biological safety. The facilities management department on the other hand, may provide the effort with specialized safety inspectors, building code inspectors, fire inspectors, accident prevention analysts, and various other safety specialists.

A tool to help the health and safety office promote decentralization of responsibility is an environmental health and safety manual. Such a publication can serve as a guide to safe practices, procedures, and emergency actions throughout the campus. Periodically the manual must be expanded, revised, and upgraded to incorporate new ideas, regulations, codes, and actions based on experience. The format can be a single manual or a series of manuals that are issued separately as the program expands and develops. However, each edition of the manual should be approved by the chief executive officer of the institution and each should contain the campus policy statement. Appropriate subjects for inclusion are applicable federal, state, and local regulations; instructions for reporting injury and illness; materials on safety; emergency preparedness plans outlining emergency action in cases of natural disasters; and other safety procedures. Copies of the manuals should be distributed to each departmental or organizational safety office.

10.4 DEPARTMENTAL PROGRAM IMPLEMENTATION

Facilities managers play a distinct role in carrying out an environmental health and safety program on campuses. As a guide to what actions they should undertake in this area, a comprehensive checklist for program implementation is provided. While the checklist serves as a comprehensive guide, it should be noted that duties will vary somewhat from campus to campus depending on the size and complexity of an institution.

Facilities Management Environmental Health and Safety Checklist

☐ Establish Departmental Policy

A facilities management departmental policy for environmental health and safety should be established and distributed to all facilities management staff. This usually takes the form of a pamphlet that gives each staff member an easy and immediate reference. The policy should adhere to the overall institutional policy but should focus specifically on facilities management responsibilities.

☐ Assign Safety Officers

Assign three levels of departmental personnel to specific duties. Assign specific staff to serve as—

- Facilities management safety officer. This person can also be a member of the Campus Environmental Health and Safety Committee.
- Unit, division, or section safety officers. Officers can be recruited from shops, grounds, custodial division, and the design group.
- Facilities Management Health and Safety Committee members. The department's safety officer can serve as committee chairperson and the unit safety officers as members. The committee will act in an advisory capacity and will report directly to the department director.

Additionally, facilities managers should take direct action on specific health and safety programs. The actions are described below.

☐ Interface on New Facilities

It cannot be emphasized too greatly that the facilities management department and the environmental health and safety office must work closely with and be consulted by the various institutional agencies responsible for the planning, purchasing, construction, and security of new facilities. Close cooperation with these parties is necessary to assure adherence to safety and environmental codes, standards, and regulations.

For this reason the facilities management department as well as the environmental health and safety office should be given an opportunity to review all design plans before construction begins. Plans should be checked for the inclusion of good environmental control principles. Also, at this stage any oversights in safety designs or omissions in accessibility to or facilities for the handicapped should be corrected. Checking for all of these items is essential since it can prevent considerable expense and unnecessary and costly reconstruction at a later date.

☐ Inspect Facilities

There are three types of inspections that should be performed.

Initial or Complete Inspection A complete inspection to determine compliance with rules and regulations should be made when a facility is first brought under the institution's control. The comprehensive check should consist of collecting basic data and information concerning the operation, physical conditions, equipment, and facilities of a new structure.

Routine Inspection A routine inspection is usually one that is conducted in response to a complaint or is an annual check on facilities to determine compliance with state or local rules and regulations.

Reinspection A reinspection is a follow-up to a routine inspection, particularly in cases where there were significant violations, to determine if the violations have been corrected. When a reinspection is made, the inspection report should be completed in its entirety. In other words, all items should be inspected, not only those that were found to be unsatisfactory at the prior inspection. Conducting a reinspection in this way will take relatively little extra time yet will ensure that deficiencies overlooked at the time of the routine inspection are noted.

☐ Establish Environmental Protection Procedures

A number of steps should be taken in the environmental area.

Prescribe Sanitary Conditions of Buildings and Grounds Set standards of safety and sanitation for university owned or occupied buildings and grounds to ensure environmentally safe and healthy conditions. These standards shall be followed during construction, maintenance, and housekeeping activities.

Establish a Program of Insect and Rodent Control To control insects and rodents on a university or college campus, the primary emphasis should be placed on basic environmental sanitation aimed at eliminating the conditions that make possible the pests' survival and reproduction. If this has been conscientiously attended to and the problem still has not been brought under adequate control, then the judicious use of the proper pesticide or rodenticide may be considered.

If proper control cannot be achieved without the use of chemicals, a chemical should be selected that is specific and has the least affect on non-target species. Only affected areas should be treated, and extreme care taken to avoid contamination of food and water. The distribution and use of pesticides are controlled by federal and state laws. In developing an insect and rodent control program, attention should be given to the following measures:

- Conduct or coordinate inspections and surveys of infestations.
- Establish adequate control for—
  - -Elimination and containment of insects and rodents.
  - -Proper handling and storage of insecticides and rodenticides.
- Adopt control measures in compliance with the Environmental Protection Agency (EPA) requirements and the U.S. Department of Agriculture (USDA) "Standards for Restricted Materials."

Develop a Program to Contain Friable Asbestos in Buildings In many structures built between 1950 and 1973, when the dangers of asbestos were unknown, insulation that contained crumbly, friable asbestos was often applied to improve a building's fireproofing, acoustic, or thermal characteristics. Today there is evidence that routine activity and air movement can cause microscopic asbestos fibers to be released from the insulation into the atmosphere, presenting a hazard to the health of building occupants. Tests and remedial measures have been prescribed by the EPA. Therefore, a campus testing program that follows EPA guidelines should be carried out in buildings of this period to determine which materials actually contain asbestos.

Following the tests, several possible steps should be taken to correct this potential problem and to comply with EPA regulations:

- Complete removal of the insulation by qualified contractors observing strict compliance procedures.
- Enclosure of the insulation by erecting a barrier (such as a false ceiling).
- Encapsulation with a sealant to contain the asbestos.

Removal is the most permanent and complete solution, although the most expensive of the three. Enclosure, by means of a barrier, or encapsulation cannot be considered total solutions. For instance, if the asbestos material is still present and it is disturbed during future repair, renovation, or maintenance work in the area, airborne fibers could once again be released into the atmosphere. However, both procedures have been used successfully to provide immediate, less costly solutions. Administrators must be aware of the limitations.

☐ Establish Safe Water Supply and Distribution

A major requirement for good health is an adequate supply of water that is of satisfactory sanitary quality. The U.S. Public Health Service has developed a drinking water standard that applies to the source, protection, and quality of water supplies. Facilities managers should develop a program to inspect and sample the campus drinking water supplies. The inspection program should follow these steps:

- Establish routine procedures for collecting water samples and testing at various locations of the college or university facilities.
- Survey the facilities to detect possible direct connections, submerged inlets, and other back siphonage conditions that could cause potential pollution.
- Establish effective control measures to prevent contamination of the potable water supply.

☐ Set Up Effective Sewage and Waste Disposal Procedures

The complexities of waste management at an institution are not always readily appreciated. Yet numerous types of waste are generated every day, ranging from paper to radioactive and industrial types of wastes. This is especially true of institutions that have high levels of scientific research activity on campus. Waste handling involves storage, collection, transfer, and transport. Processing includes incineration, compacting, separation, and treatment. A comprehensive waste management program will require the input of many specialists. Facilities managers should develop these procedures:

- Establish control measures for the proper disposal of sewage, garbage, and refuse that meet local and state minimum requirements.
- Establish a program for the collection, storage, and disposal of hazardous waste substances that meets U.S. Environmental Protection Agency and U.S. Department of Transportation requirements. This should be done in cooperation with the campus Office of Environmental Health and Safety. The program should deal with flammables and combustibles; explosives and old ethers; and carcinogenic biohazardous, and other hazardous materials delineated by the above-mentioned federal agencies.

☐ Implement Monitoring Program for Swimming Pools

It is known that certain illnesses can be transmitted by improperly operated swimming pools. The sanitary quality of swimming pool water is determined by performing certain bacteriological, chemical, and physical tests. Samples must be obtained within standard methods for these tests. Establish a monitoring program for swimming pools in the following areas:

- Testing of bacteria, chlorine, pH, and alkalinity of pool water.
- Construction, operation, and maintenance of pools in accordance with the American Public Health Association report, *Public Swimming Pools: Recommended Regulations for Design and Construction, Operation and Maintenance.*[1]

☐ Develop Occupational Health and Safety Measures

Certain practices are designed to prevent or control conditions in the workplace that may cause occupational sickness or accidental injury. The following are preventive and control measures that should be taken by facilities management:

- Adopt health and safety standards for industrial operations that take place in shops, laboratories, storerooms, garages, and other owned or operated buildings that fall within the jurisdiction of facilities management. The standards should be of equal stringency to federal Occupational Safety and Health Administration (OSHA) standards.
- Set up controls for the purchase, storage, and application of pesticides and cleaners.
- Establish guidelines for the proper use of protective devices used by employees in facilities management shops. Guidelines should note the type of protective clothing and equipment, such as goggles and respirators, needed. Rules should designate how and when the protective equipment should be used.

An occupational health and safety inspection is designed to note, evaluate, and control some conditions in the workplace that may cause occupational illness or accidental injury. During an occupational health and safety inspection the shops, garages, and grounds under facilities management jurisdiction should be checked for—

- Compliance with safety and preventive health measures.
- Proper labeling and storage of chemicals, pesticides, and toxic materials used in facilities management operations.
- Safe disposal of hazardous waste materials.
- Presence of properly designed and operated ventilation hoods.

- Proper lighting and noise suppression.
- Operation of an ongoing PCB control program that includes the identification, marking, regular inspection, and ultimate proper disposal of transformers, capacitors, and high-voltage switches that contain PCB oils.

In addition, other items in the inspection to be investigated are:

- Presence of battery acid spills.
- Existence of fire hazards.
- Conditions in maintenance garages that create asbestos exposure. Asbestos can be released during brake shoe grinding or similar occupational activities.

☐ Implement Accident Prevention Strategies

Maintaining records of accidents and injuries is essential to the operation of a successful safety program. Records supply the information needed to direct an effective safety effort that controls both working conditions and conduct that contribute to accidents. Below are accident prevention measures that should be taken by facilities managers.

- Establish safety standards for all student and regular personnel employed by the department.
- Establish safety standards for public activities sponsored or officially approved by the university or college.
- Maintain records for and make an epidemiological study of accidents.
- Establish and promote safety training programs.
- Extend the vehicular safety program where needed if this falls under the jurisdiction of facilities management.
- Investigate the physical requirements for job acceptance and preemployment health evaluation.

☐ Devise Disaster Preparedness Plans

No institution is immune from disasters. Emergencies ranging from tornadoes to chemical spills can arise at any time and from many causes. Planning for emergencies, like other management functions, must be done in advance so that it can be used as a basis for decision making should a disaster occur. While such plans cannot guarantee prevention of an emergency, they can help mitigate its affects or even forestall its initiation—thus minimizing potential harm to people and property. A Plan for Emergency Preparedness should include methods of procedure for—

- Civil defense that incorporates a description of the shelter location, methods of manning the shelter, and a system for stocking the facility.
- Epidemics.
- Natural disasters such as hurricanes, earthquakes, tornadoes, and floods.
- Chemical, carcinogenic, or mutagenic spills.
- Biohazard emergencies.
- Radiation emergencies.
- Civil disturbances.
- Labor strikes.
- Bomb threats.
- Laboratory explosions or threats of explosions.
- Fires.

10.5 CONCLUSION

All colleges and universities must act on organizational and policy matters concerning environmental health and safety. In addition, they have a great many operational responsibilities. For example, they have ultimate accountability for disposal of pathological wastes from hospital and veterinary facilities, disposition of chemicals and biological materials, and compliance with regulations that pertain to research animals.

This chapter has discussed the specific responsibilities customarily delegated to facilities managers. The facilities management department may be assigned specific functions related to these responsibilities such as transporting or incinerating hazardous wastes. In such instances it is the usual practice for the institutional office charged with comprehensive responsibility for campus health and safety to issue facilities managers specific directions on how to conduct the operation properly as well as protect staff.

Environmental health and safety requires more attention as new materials emerge and knowledge expands on the affects of materials on our environment. This calls for administrators, engineers, chemists, safety experts, and other professionals to keep abreast of developments in the field in order to discharge their duties properly and protect the public welfare.

END NOTE

1. Eric W. Mood, editor, *Public Swimming Pools: Recommended Regulations for Design and Construction, Operation and Maintenance* (Washington, D.C.: American Public Health Association, 1981).

CHAPTER 11

Auxiliary Enterprises

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Supporting or servicing auxiliary enterprises, unique campus operations, need not present a dilemma to the plant director. Instead, by developing both a method of approach and a policy with the budget staff, the ambiguities sometimes associated with auxiliary enterprises can often be relieved.

11.1 GROUPS DEFINED

The National Association of College and University Business Officers (NACUBO) defines auxiliary enterprises as those campus operations that furnish services directly or indirectly to students, faculty, and/or staff and that charge a fee related to—but not necessarily equal to—the cost of the service. At publicly funded institutions, they are sometimes referred to as nonappropriated fund activities because they are not supported with appropriated funds.

Auxiliary enterprises are distinguished from others because they are managed essentially as self-supporting activities, with the exception of some student service fees or other fees earmarked to help sustain the activities. Commonly, auxiliary enterprises are funded separately from the education and general funds of an institution and do not necessarily serve all students.

Good examples of auxiliary enterprises are housing, food service, and campus bookstores. Others might include the student union, recreational facilities, campus bus service, intercollegiate athletics department (as distinct from the instructional department of physical education), and campus parking facilities. Certain research facilities, such as nuclear reactors that are self-supporting, may also fall under the rubric of auxiliary enterprises.

Auxiliary directors usually find that it is more convenient and economical to make use of the plant department's facilities engineering, maintenance, and management capabilities than to duplicate those capabilities or use outside consultants and contractors. This creates a unique situation in which the plant department acts as advisor and contractor in furnishing services requested by each enterprise while also exercising certain authority in matters pertaining to regulations and engineering practices. For example, plant administrators may advise auxiliary enterprise officials on compliance with institutional and government codes and regulations as well as sound engineering practices. To meet that need, planning and coordination procedures must be developed.

The unique status of auxiliary enterprises creates other ramifications for plant departments. For instance, each enterprise is managed as a separate facility with individual cost accounting. Each one has institutional objectives—such as student recruitment and retention or providing essential student services. Beyond these objectives, however, each is managed largely as a commercial enterprise in which the level of service provided is matched to what users are willing to pay. As a result, maintenance and service levels, as well as priorities designated for work projects, may differ from those at facilities directly funded and managed by the plant department.

11.2 BUDGET CONTROL

Another way to define an auxiliary enterprise is anything for which the plant department is not budgeted, or, in some cases, is provided for separately; for if all were drawing from the same budget pool, auxiliary facilities would be competing along with classroom and office facilities for maintenance services, adding to budget control problems for the plant director. If, in fact, this *is* the case at an institution, the plant director needs to work with the budget director and other departments involved to set up an allocation of available resources. Otherwise, "the squeaky wheel gets the oil" maxim is likely to prevail.

If there is no allocation mechanism for auxiliaries at an institution, a meeting with the budget director is needed in which auxiliary enterprises are clearly identified and resources allocated. Colleges and universities must have cost accounting methods to evaluate, analyze, and control income and expense items of the auxiliary operations which make it possible to establish appropriate fees and prices. While this may mean adding accounts, it does assure proper resource control and reveals actual costs to the institution. An added advantage to this method is that the process forces each auxiliary service to justify its own budget rather than require the plant director to do so. If separate allocations are not possible, then the plant director may find it beneficial to budget the available resources among all the divisions for which he or she is responsible, including auxiliary enterprises. The plan must be shared with the heads of these divisions and their cooperation secured. While this method is not preferable, it is better than taking no action at all.

11.3 ORGANIZATIONAL VARIATIONS

The management of finances and people should be under the control of the auxiliary director who best knows the operation. However, it is not uncommon to have maintenance and custodial personnel assigned to the plant department do the work for the auxiliary enterprise, with the auxiliary getting charged for costs as they occur. Some auxiliaries use a combination system: residence halls may maintain their own custodial and even small maintenance staff, but the plant department will provide services and assistance that are more specialized—for example, HVAC systems service, elevator repair, and electrical maintenance. This arrangement ensures a certain amount of flexibility and prevents duplication. Where those specialized services are available through the plant department, auxiliary directors should not call upon outside contractors.

The institution's size and that of the auxiliary will probably dictate how staffs are assigned. Auxiliaries at smaller schools will tend to use the physical plant as their resource pool in order to gain maximum flexibility. As the college expands along with an auxiliary enterprise, it may become not only desirable but also feasible for an auxiliary operation to financially support its own maintenance staff.

A word of caution: Care must be taken to ensure that in areas where plant personnel are providing services, the auxiliary enterprise does not assume supervisory authority; for if control of personnel is lost, flexibility and credit for accomplishments will also be lost.

11.4 PROGRAM PLANNING

It is never good to work in a vacuum, and both the facilities and auxiliary enterprise staffs need to work together—particularly during budget preparation time. As stated above, each auxiliary operation needs to draft and justify its own budget. However, the plant director needs to participate in this process and assure agreement by both plant and auxiliary departments on types and levels of services anticipated for the budget period.

A starting point considers the level of service provided in the past as a base and then anticipates new requirements for the coming year. This is easy to do when separate auxiliary accounts are kept. For example, in the past the plant department may have had four workyears of grounds work dedicated to the needs of the intercollegiate athletic department. However, in the upcoming year, with new emphasis being placed on women's sports, the department wants to upgrade the condition of the women's playing fields. Another one-half of a full-time person's services is needed to accomplish the job. Intercollegiate athletics needs to recognize the expanded maintenance needs and, once agreed upon, include them in their budget for the next program year. The plant director, on the other hand, needs to staff for this additional requirement either by reallocating current resources or securing additional positions.

For auxiliaries, one-time major costs or capital improvements require scrutiny. Good examples of typical one-time needs are reroofing a building or replacing a chiller in an auxiliary facility. If the plant department carries out a reliable yearly comprehensive building inspection (in addition to a preventive maintenance program), these capital improvement items can be identified. A special reserve fund for one-time costs should be maintained separately from the annual operations, maintenance, and repair budget. A good preventive maintenance inspection should also identify areas that the building inspection team should examine in detail.

11.5 SPECIAL SERVICES

Facility Planning and Design Assistance

Part V, "Planning, Design, and Construction," discusses the design and execution of facilities projects both with in-house personnel and with consultants and contractors. Auxiliary enterprises usually rely on the plant department to either design and carry out projects with their own crews or to work with outside consultants in the design and execution of projects by contractors.

Facility Evaluations

The effective management of facilities, including the budgeting step, demands advance planning since the task involves projecting fund requirements for a several year span. Auxiliary enterprise directors look to the plant department for certain technical expertise before assembling their budget figures. For instance, plant departments are often asked to perform evaluations in three general categories:

- Status of compliance with codes and standards, particularly those that are new or changed.
- Current condition of facilities and appraisal of repair requirements.
- Energy efficiency of buildings as well as mechanical and electrical equipment. The evaluation may include recommendations for improvements.

Preventive Maintenance

Preventive maintenance (PM) must not be overlooked in auxiliary facilities. The best way to deal with upkeep is to assign total responsibility for the institution's campus-wide preventive maintenance program—including all auxiliary facilities—to the plant department.

As an alternative approach, the auxiliary enterprise can establish its own preventive maintenance program modeled on the one used by the plant department. If the auxiliary uses its own maintenance staff to do this, the plant director should help them establish a good PM program and show them how to stick to it.

Preventive maintenance inspectors work for the physical plant, but, as we have mentioned, they often inspect auxiliary facilities. On the charge-back, only costs of the actual inspection should be billed to the auxiliary. Since inspection fees are fixed costs, the auxiliary should be able to budget for them fairly easily. An alternate method allocates such costs to each auxiliary using a prorated share based on a common denominator such as square footage. In any case, whatever maintenance and repair items are identified should be handled by the auxiliary maintenance staff if one exists. If something beyond their capability arises, it should be taken care of by the plant's maintenance shops and billed to the auxiliary on the charge-back system described earlier. It is good business practice to have an agreement on what can be done by the plant department in an auxiliary facility without prior approval from the auxiliary's management. Otherwise there can be a significant delay in obtaining the necessary approvals to get the work accomplished.

Energy Management and Electric Load Shedding

The plant department usually manages energy usage for the entire campus. However, managers of individual auxiliary enterprises, which pay for the energy used, must participate in formulating and executing the energy conservation program for their operations. A major problem area in energy management is electric load shedding. Since rates for purchased electricity include both demand and usage charges, all users must participate in limiting the demand. It is the plant department's job to work with all users to determine peak demand and to establish a load shedding schedule to avoid exceeding the set limit.

11.6 DEFINED RESPONSIBILITIES

Servicing auxiliaries can be challenging, but there is a need for collaboration and well-defined roles. In spite of sometimes having to wear several hats, the plant director is the key person to make this cooperative effort successful. By gracefully accepting auxiliary enterprises and serving them skillfully, plant directors serve the overall mission of education at their institutions. At the same time, directors can build a positive reputation and support within the institution for plant employees and the department. The end result is that everyone wins.

CHAPTER 12

Location of Plant Facilities

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12.1 BACKGROUND AND SCOPE

Explosive growth in college and university enrollments during the 1950s and 1960s prompted a heavy emphasis on the construction of new campus facilities. The major building efforts were devoted to providing essential teaching and research facilities to keep pace with expanding numbers of students. This "edifice complex," coupled with an inability to predict the rate or ultimate extent of expansion, made effective campus planning difficult. Campus master plans repeatedly were revised as enrollments exceeded expectations. Campuses pushed beyond their boundaries and development failed to keep up with the increase of facilities.

As enrollments stabilized over the years and facilities requirements came to be projected with greater accuracy, it has become viable to reevaluate campuses on their functional effectiveness. Possible future enrollment reductions, which will permit removal of facilities with accompanying cuts in energy and maintenance costs, have given an added impetus to campus planning. These evaluations are resulting in campus improvement projects; revised pedestrian and vehicle traffic circulation systems; and the relocation of academic, administrative, and support organizations.

Traditionally, the college or university campus has served specific functions at institutions that can be grouped into five categories. For instance, the campus:

- Creates a sense of place as well as a recognizable cohesive area that is distinct from its surroundings. Typically, this is accomplished by the use of landscaping, lighting, and signage.
- Promotes student assembly and interaction by the strategic location of plazas, malls, outdoor furniture, shelters, and lights.
- Provides for student movement between classes and to and from such facilities as libraries and unions.

- Creates a quiet and aesthetically pleasing environment that is conducive to learning.
- Facilitates the effective handling of service and support functions—such as utility production and distribution, trash removal, and maintenance—while minimizing interference with the institution's teaching and research functions.

Physical plant functions fall in the last category and good planning can minimize the natural tension between the functions. However, poor planning in arranging for the extensive support facilities and functions of the plant department can result in either excessive operations and maintenance costs or in interference with the other campus functions.

The paramount concerns of most professional campus planners and officials who make facilities assignments are with the first four categories of campus functions. They look to the physical plant professionals for information on the service and support functions and how they impinge on the location of plant department facilities. Those factors of concern in the location of plant department facilities apply to the contruction of new or replacement facilities as well as to making improvements to current structures.

12.2 PLANT DEPARTMENT FACILITIES

The basic task of the plant department is to perform assigned service and support responsibilities with optimum effectiveness and efficiency yet with minimal interference with the primary mission of the institution. In the workaday world, a satisfactory balance must be struck between plant department efficiency and its adverse effect on the institution's teaching and research missions. In arriving at a balance, it should be remembered that the service and support functions of the plant department are the most costly aspects of the educational process.

The functions that are assigned to the plant department vary from institution to institution. The facilities needed will consequently vary. However, all require careful evaluation regarding siting. The most common facilities are:

- Central power or heating plant.
- Central chiller plant.
- Utility distribution lines (electricity, steam or hot water, drinking water, natural gas, liquid waste).
- Plant department administrative facilities.
- Skilled trades shops.
- College or university key shop.
- Garage and motor pool.
- Motor vehicle and equipment parks (for storage of backhoes, rollers, mowers, front loaders, trenchers, graders, snowplows, pickup trucks, etc.).

- Warehouses.
- Nursery or plant storage areas.
- Solid waste incineration plant.
- Plant department employee parking.

12.3 FACTORS AFFECTING FACILITIES LOCATION

The factors to be considered in determining the locations of plant department facilities are:

- Accessibility to outside agencies or facilities.
- Access routes for maintenance and service vehicles.
- Routing of utility distribution systems.
- Coordination with other offices or departments of the college or university.
- Operational integrity of the plant department.
- Campus architectural harmony.

Accessibility to Outside Agencies or Services

This consideration affects only two types of outside agencies or services: commercial transportation facilities and commercial utilities services.

Plant department receiving facilities should be located convenient to commercial transportation lines. This is necessary since the plant department routinely receives large quantities of supplies and materials. The major types of supplies and equipment that the plant department receives are:

- Coal for a coal-fired power or heating plant.
- Bulky materials such as air handlers, refrigeration equipment, heating or cooling coils, lumber, masonry goods, steam or water piping, laboratory furniture and growth chambers, high-voltage electric cable, transformers, and electric motors. All of these items are typically delivered directly to the plant department.
- Expendable supplies such as filters, water treatment chemicals, fertilizers, seeds, plants and shrubs, and custodial suplies.

The above materials may be delivered either to the central plant warehouse or to individual shops. The receiving facility should be located in a place convenient to commercial transportation lines so that it can be reached with a minimum of travel through the campus. The location of coal-fired utility plants is especially important. Nothing could be more distracting than coal trucks traversing a campus and unloading in the vicinity of academic facilities.

Campus utilities facilities should be sited close to commercial service distribution lines since most college and universities buy at least some portion of their utilities. The point at which purchased utilities are connected to a college or university distribution system is of little concern for natural gas, water, and liquid sewage systems. It is quite another matter for purchased electric service that is disbursed through an institution's distribution system because that requires a switching station at the point of entry. Due to the unsightly appearance of switching stations, it is recommended that they be kept in reasonably isolated areas. However, there may be limited flexibility in siting due to the location of the commercial distribution lines. For example, typical utilization voltages of a college or university system are between 12,000 and 14,000 volts, and line losses would be comparatively high if the electricity were to be transmitted over appreciable distances. Therefore, the closest proximity to commercial lines that will not detract from the architectural harmony of the campus is preferable.

Access Routes for Maintenance and Service Vehicles

A plant department is labor intensive. Several hundred workers may be deployed daily to various parts of the campus. Work assignments will vary from day to day, even hour to hour. At most institutions workers are required to report to trades shops, from there to be transported with tools and materials to work locations. This necessitates the movement of a large number of motor vehicles and pieces of equipment throughout the campus. Distraction can be minimized by using circuitous routes or establishing satellite maintenance and service centers on campus. Having workers report to these satellite centers, where repair parts, tools, and equipment are stored, can cut down on travel. (See Part III, Chapter 5, "Management of Maintenance Stores" for discussion of location.)

Routing of Utility Distribution Systems

Chapter 3, "Utility Distribution Systems," discussed the comparative advantages and disadvantages of various ways to install utility lines such as overhead or underground electrical lines. It also outlined the various methods of installing underground steam and water lines. There are several additional factors to consider regarding the effect of routing on the campus environment.

Where possible, lines should be installed underground so that there is minimal interference with permanent campus facilities. When lines are installed beneath malls and plazas, however, repair and replacement of steam, water, and gas lines are difficult and costly and interfere with facility use. If facilities such as malls and plazas are installed after utility lines are in place, it may be desirable to relocate the lines as part of the construction project. In either case, the problem should be brought to the attention of the decision-making authority.

Manholes, which provide access for repair and replacement of underground distribution equipment, should be located for easy access from roads and drives so that vehicles and equipment need not be moved across lawns.

If underground utility lines are being installed, consideration should be given to the difficulties of changing landscaped areas once the underground lines are in place. Surface elevations cannot be changed appreciably without relocating the utility lines.

Coordination with Other Offices and Departments

The departments and offices with which the plant department interacts most often are—

- Purchasing department.
- Central receiving/central stores (typically a part of purchasing).
- Budget office.
- Comptroller's office.
- Personnel office.
- President's and vice-president's offices.

Additionally, the plant department is frequently visited by other campus officials such as deans and department heads with regard to the design, funding, and status of work projects. Consideration should be given to making the plant department's administrative offices accessible to the other campus offices with which it conducts most business.

Plant Department Operational Integrity

Consideration of the above factors may lead plant administrators to conclude that dispersing plant department facilities may be the best arrangement. Before arriving at that decision, managers should consider how the facility's location will affect the unique leadership and coordination requirements of the plant department. A plant department is labor intensive, and in order to achieve optimum economy requires maximum productivity from individuals. This results from effective supervision, coordination, and identification of the individual with the organization, best achieved by grouping as much of the organization as possible in a single location.

Campus Architectural Harmony

Most physical plant department facilities such as the central plants, electric switching stations and substations, trades shops, warehouses, and motor pools, tend to resemble industrial facilities. It is difficult, if not impossible, to make them compatible with the architecture of a college or university campus. To minimize the adverse effect on the aesthetics of the campus, it may be desirable to group all the facilities in one industrial area that is remote from the core of the campus or to site them as inconspicuously as possible throughout the campus.

12.4 SUMMARY

The two basic considerations in locating plant department facilities are effectiveness and economy in carrying out service and support functions that minimize interference with the institution's missions. Specific factors should be evaluated before deciding on the locations so that balance can be achieved between these two conflicting requirements. Any siting decision must be evaluated both with regard to the current campus as well as to anticipated changes.

CHAPTER 13

Telephone Systems

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13.1 INTRODUCTION

In the past, few if any colleges or universities owned and operated their own telephone systems. A change in attitude toward competition in the telecommunications industry by the Federal Communications Commission during the early 1980s, combined with the rapidly changing technology of telephone systems, has caused the prospect of an owned telephone system to become much more attractive. With rates for local telephone service expected to rise rapidly through at least 1987, many institutions will be forced to consider purchasing their own system if for no other reason than to control their costs for telephone service.

A modern telephone system is a complex utility that is something of a cross between a computer system and an electrical distribution system. In addition to transmitting human conversations, the modern telephone system will support data transmission and has the capability to serve as the hub for security systems, building access control systems, energy management systems, radio paging, fire and intrusion alarms, electronic mail, and voice mail. In most institutions the telephone system operations will be handled by a telephone or telecommunications office that may or may not be administratively part of the physical plant. Regardless of the structure, the plant department will be deeply involved in any institutionally owned telephone system because of the need for both inside and outside wiring. Additionally, the plant department will be drawn in as telephone systems are applied in new ways in energy management and alarm systems.

This chapter is devoted to a discussion of the types of telephone systems found on most campuses—which are usually provided by the regulated local telephone operating company—and the four major components of an owned telephone system (the switch, outside plant, inside wiring, and terminal equipment).

13.2 FUNDAMENTAL TERMINOLOGY

In order to better understand what kinds of systems are appropriate for an institution, it is best to explain a few terms that are fundamental to telephone service. With this groundwork laid, the discussion will move to the basic types of telephone service bound to be encountered on university or college campuses.

The *public switched network* is the mechanism for providing the necessary interconnections to allow two telephones to communicate. Looking at communications closely, it becomes apparent that the ultimate usefulness of any telephone system is to enable a user of the system to communicate with any other telephone user—whether in the next room or halfway around the world. In North America the public switched network is the aggregation of some 1,540 telephone companies and long-distance carriers such as AT&T Communications. Any privately owned telephone system must be interfaced with the public switched network, usually through the local telephone company.

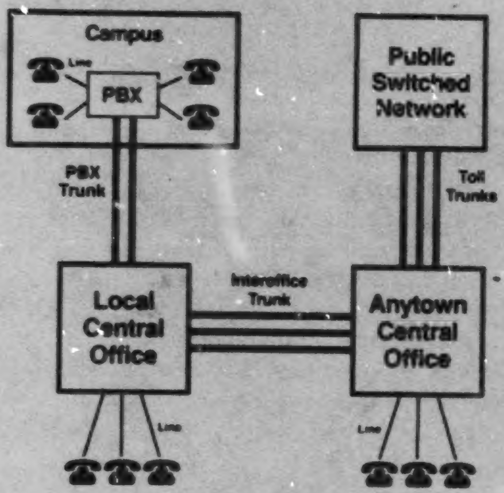
The *central office*, sometimes called the local office or exchange, is where a single telephone line and a privately owned telephone system both interface with the public switched network. Conceptually, the central office is, for outgoing calls, the processor that "recognizes" the dialed telephone number and initiates the interconnection sequence for it whether that number is served by the same central office, whether it is located across town, or whether it is situated in another state or another country. Conversely, for incoming calls a central office is the final link to a called number regardless of the call's origin. A private telephone system functions much like a central office.

The last of the fundamental terms readers will need to become acquainted with are some basic components called lines and trunks. A *line* connects a single telephone set, or a single telephone set and its extensions, to a central office or to the owned telephone switch. It is a dedicated physical path from the instrument to the central office or owned switch. A *trunk* connects two central offices. It is used to complete the connection when a call is placed from a line connected to one central office to a line connected to the other central office. Since there are far fewer trunks between central offices than there are possible connections, the system seizes a trunk on an "as-available" basis to complete a connection. If all trunks are in use, the caller hears a busy signal. Most privately owned telephone systems are connected to the public switched network through a central office of the local telephone operating company via trunks. (See Figure 13-1.)

13.3 BASIC TELEPHONE SERVICE TYPES

On any particular campus, four basic types of telephone service may be encountered: single line, key telephone system, Centrex, and dedicated

Figure 13-1
Relationship of Campus PBX to Public Telephone Network



telephone switch. Some of these services are available only from the local regulated telephone company, while others may be obtained either from the serving telephone company or through a privately owned system.

Single Line

The most fundamental type of service is the single line, also called private line or residential service. With it the user has a single telephone number and a simple single-line instrument that may include extensions. This type of service is generally not found in the mainstream of campus telephone activity. But it may be found at outlying or remote locations where it is less expensive to hook up to the local central office than to tie into the campus telephone system. Single-line service may also be found on campuses in order to meet unusual data transmission needs or, where necessary, to bypass the campus telephone system for long-distance calling.

Key Telephone System

A service commonly found on campuses, whether or not the institution owns its own system or obtains service from the local telephone company, is the key telephone system. With this system several lines from either a central office or the switch of an owned telephone system terminate in a key service unit. The number of lines typically ranges from 2 to 10 but sometimes is greater. Attached to the key service unit are a number of key telephones—usually 10 to 50, though sometimes more. Each phone has a panel of buttons that correspond to some or all of the lines coming into the key service unit. When a call comes in, a bell rings or a chime sounds to announce the call. At the same time, a light blinks on the button corresponding to the incoming line; the light flashes on every key set on which the line appears. At that point, any party at one of these sets can answer the call. To place an outgoing call the party selects a line by pushing any unlit button, picking up the receiver, and listening for a dial tone.

The typical way to use a key telephone system is to have an attendant answer and route all incoming calls by means of an intercom. The principal advantage of a key telephone system is that the number of lines required to service a given number of people is far fewer than if each person had a dedicated line. This in turn translates into lower costs. On the other hand, there are disadvantages to a key telephone system. One is its high relative cost. Key telephone sets cost a great deal more than a single-line instrument. Furthermore, expensive cabling is required and an attendant is mandatory in most situations. Aside from cost, key systems usually lack many of the features of the more modern telephone systems.

Centrex

Another type of telephone service found on many college and university campuses is called Centrex. Centrex is no more than a packaging of many single lines to meet some of the basic intraorganizational communication needs of an institution. With Centrex service, a block of telephone numbers is reserved and assigned to the institution. To place an intrainstitutional call an on-campus caller uses abbreviated dialing in which only four or five digits are dialed rather than the usual seven required for conventional single-line service. Calls placed from outside the institution go directly to the called station by dialing the station's unique seven-digit number. There is no need for an attendant. Outgoing calls—that is, those going off campus—require a special digit to be dialed to obtain central office dial tone. (Thus the familiar "dial nine for outside" instruction.) The outgoing call is then placed in the usual way. Other special digits may be used to access various long-distance services.

Except for the capability to place and receive calls directly, most Centrex services possess only rudimentary additional features. These include call transfer, consultation (the ability to place the caller on hold and make another call using the same line), and conferencing. Conferencing is usually set up by the Centrex operator. Depending on the actual equipment that the local serving telephone company uses to provide the Centrex service, additional features such as speed dialing (in which prestored, frequently-used telephone numbers can be activated by dialing a short code) may be available. It is important to remember that Centrex is a packaging of services by the local telephone company and does not represent any particular type of equipment. There would never, for example, be an owned Centrex service because Centrex is a concept rather than a physical entity.

Dedicated Telephone Switch

The type of service most commonly found on campuses is the dedicated telephone switch, whether owned by the institution or furnished by the local telephone company. The telephone switch is usually referred to as PBX (private branch exchange). It is sometimes called an EAPBX (electronic automatic private branch exchange). There are many PBX vendors, some of which have their own names for the switch. PBX, however, is the most universally accepted term.

A PBX functions much like a telephone company central office with the exception that it usually does not have the capability to interface directly with the toll portion of the public switched network. Instead, the PBX interfaces with a central office of the local telephone company. The local phone company, in turn, provides the interface with the toll network. Of course, to every rule there will be an exception. If a campus PBX happens to be a central office-type of equipment rather than a standard PBX, it could interface directly with the toll network—a rare but not impossible situation. The PBX will be explained in greater detail in the next part of the chapter, which examines the four major components of a campus telephone system.

13.4 CAMPUS TELEPHONE SYSTEM COMPOSITION

A typical campus telephone system has four major components: the PBX or telephone switch, the outside plant, inside or house wiring, and terminal equipment such as telephones.

PBX

The PBX is the heart of any campus telephone system. Most PBXs, whether purchased by the institution or installed by the local telephone company since 1973, will be electronic, while PBXs older than that may either be electronic or electromechanical. The classification of a PBX as either electronic or electromechanical describes the method used to interpret the digits that come from a telephone instrument, be it rotary dial (which sends pulses) or pushbutton (which sends tones). An electromechanical switch will use the digits to drive directly either mechanical relays or step switches to set up a physical path between the calling and called line. An electronic switch uses a special-purpose computer to interpret the incoming digits and then issue commands to the actual switching matrix to establish the physical connection.

The electronic PBX, because it has an internal computer that can be programmed for a variety of functions, is much more versatile than the electromechanical PBX. The electronic PBX also consumes less floor space and power, generates less heat, and is more reliable than the electromechanical type.

The newer electronic PBXs are often referred to as digital PBXs. Digital refers to the method used to actually pass a conversation or signal through the switching matrix of the PBX. A telephone conversation is analog in that it consists of a composite of many frequencies and amplitudes, as contrasted to digital computer data that consist only of bits (ones and zeros). A digital PBX converts the analog conversation into a digital form, consisting only of ones and zeros, either at the telephone instrument or at the PBX. With the conversation in digitized form, a digital PBX actually uses the computer memory to move the bits from the calling line to the called line, i.e., to make the connection. This is contrasted to making an analog connection where there must be a physical conducting path that conducts the signal through the switch to complete the connection.

The reasons for the move toward the digital PBX are several. First, digitizing eliminates virtually all mechanical parts in the PBX, which translates into reduced size, lower power consumption, less heat generation, and greatly improved reliability. With the continued development of integrated electronic circuit technology the per-line prices of digital PBXs continue to drop. With voice being digitized the PBX is equally adept at handling both voice and data. This is extremely important in light of the proliferation of computers and computer terminal devices. Finally, with both the control information from a telephone (the digits touched) and the message (the actual conversation) being processed by a computer program, a variety of features are available that are not practical or even possible with either an electromechanical PBX or an electronic PBX with an analog switching matrix. The newer PBXs support more than 100 features, some of which are quite obscure. The more common features include call transfer, call forwarding (in which an incoming call can be automatically routed to another number), camp on (in which the system can "camp" on a busy line and ring back the caller when the line becomes free), and call pickup (which allows a person at a line other than the called one to answer an incoming call).

A PBX is connected to the local central office by trunks while the users of the PBX are connected to it by lines. The lines on a PBX greatly outnumber the trunks. Generally speaking, trunks are either incoming or outgoing. Incoming trunks carry calls from outside the PBX to lines that terminate on the PBX. Most newer PBXs support what is known as direct inward dialing (DID). This mechanism allows a call from the outside to be connected automatically to the line for which it was intended. PBXs without DID require operators to answer all incoming calls and to notify the called party of the call. Outgoing calls require a special digit to be dialed to access the outgoing trunks and obtain central office dial tone. If all the campus outgoing trunks are already in use, a caller trying to call off campus will obtain a busy signal. Similarly, an incoming caller will hear a busy signal if all the incoming trunks are in use.

One of the more attractive features of the modern PBX is the so-called "least-cost routing feature" for toll calling. Because the number being called is processed by a computer, a program in the computer can examine the number and determine which of several alternate long-distance methods will result in the lowest cost. Possible alternate long-distance methods include WATS (wide area telecommunications service), long-distance carrier service other than AT&T, tie lines between the campus PBX and another PBX such as one at a remote campus, foreign exchange lines connecting the campus PBX to a telephone company central office in an area of high-calling density, and privately owned communications facilities connecting campuses.[1]

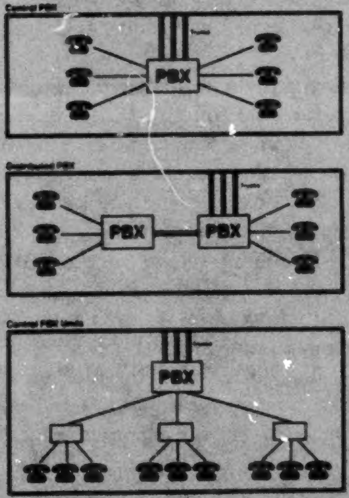
In addition to carrying voice traffic the modern digital PBX can also be used to carry data traffic between computers and terminals of all kinds. The PBX may also carry sensor data from energy management systems, fire detection systems, instrusion alarms, and even units such as centralized time clocks. In reality, the usefulness of the digital PBX in areas other than normal voice traffic is limited only by the foresight and innovativeness of the institution and its personnel.

Outside Plant

Outside plant denotes the cabling used to connect the PBX to all buildings and structures that contain equipment served by the PBX. The outside plant is similar to the electrical distribution system of the campus. Indeed, in many places they parallel each other. Outside plant can be either aerial or underground. Most underground outside plants are run through cable vaults or utility tunnels, although direct burial is sometimes encountered. Aerial outside plant is generally to be avoided in most campus situations due both to its unattractiveness and susceptibility to damage. Conventional outside plant is primarily composed of cabling consisting of from 240 to 1,200 pairs of wire. Under normal circumstances 2 or 3 pairs will service a single line. Often the cable core will contain one or more coaxial cables and even possibly video pairs. Depending upon the installation, the cable may be pressurized with an inert gas such as nitrogen.

Modern PBX design falls into one of three categories: the completely centralized unit in which all lines in the system terminate in one physical unit at one location, a distributed system in which two or more units of equal capability are located in geographically separate locations and cabled together, or a central main PBX unit connected to remote peripheral cabinets by some kind of cabling. (See Figure 13-2.) When connecting units of a distributed system or remote peripheral cabinets to the central unit, conventional twisted

Figure 13-2
Typical Campus PBX Configurations



pair cabling is generally not used. Instead, coaxial, fiber-optic, or other high-speed cabling is required. In certain unusual cases, such as where there is a need to cross a public right-of-way, microwave radio may be used in place of cabling.

Inside Wiring

Inside wiring refers to the building wiring that connects the actual telephone equipment to the junction panel where the outside plant terminates. In multi-story buildings there will be riser cables running to a distribution panel for each floor. The numbers and sizes of these risers depend directly upon the number and types of terminal equipment installed. Cabling from the distribution panel to the actual instruments is a function of the types of equipment and service. For key telephone systems and multi-line instruments, the normal cable is 25-pair cable. Two or more of the 25-pair cables may have to go to a single instrument, depending upon the number of lines involved. The cables do not terminate in the actual instrument, but rather in a junction box or connecter to which the instrument is connected. Single-line instruments attached to older electromechanical systems are usually connected by a single-pair cable. Inside wiring for a modern PBX system is far simpler and less costly than for the older systems. Depending upon the PBX manufacturer, cabling to the instrument will consist of either two, three, or four pairs regardless of the type of instrument used.

With older telephone systems one of the more time-consuming and costly procedures is accommodating moves and number changes. At the least, it usually requires recabling at a riser distribution panel. At the extreme, it may require recabling at the PBX, junction with the outside plant, and pulling new cable. With the modern PBX, however, these requirements are virtually eliminated. Since the PBX is a computer, it is programmed with a table that associates a given telephone number with a particular physical line. To move or change that telephone number simply requires changing the table of lines to telephone numbers. Typically this reprogramming is done through a terminal attached to the PBX. Of course, this simple method of rematching lines and numbers will only work if, during initial system installation, all locations that might ever need telephone service are prewired, whether the wiring is used immediately or not. This should be borne in mind when dealing with new construction or remodeling. It is far cheaper to install an abundance of cabling during initial construction than to pull in new cabling after completion.

Terminal Equipment

Telephone terminal equipment comes in almost endless varieties. However, when all the vendor promotions and special features are stripped away, only three types of telephone instruments emerge: single-line, multi-line, and electronic.

The electronic set is associated with the electronic PBX and combines the features of a single-line and multi-line instrument. It requires only two, three, or four pairs to connect (depending upon the vendor), but allows for many numbers to be directed to the line associated with the instrument. That is, several telephone numbers are all associated with one line.

Some electronic instruments have a small, built-in display unit that shows time and date, number being called, time of call, and even the number from which an incoming call originated. Sets connected to a PBX that supports voice mail may contain a "message waiting" indicator.

More complicated electronic sets incorporate a computer terminal with the telephone portion of the set. A set will typically consist of a display screen and a typewriter-like keyboard. With these sets simultaneous use of the instrument as a telephone and computer terminal is possible.

There are two methods of signaling or "dialing"—pulse and tone. Pulse signaling is usually associated with rotary dial instruments, while tone signaling is usually associated with pushbutton instruments. However, care must be taken when choosing instruments because many instruments with pushbutton calling actually generate pulse signals. This is particularly true of the so-called "cordless" telephones. Pulse telephones will usually work with all PBXs and central offices, though there are exceptions to every rule. Tone telephones, however, will not work with PBXs or central offices that accept pulse-only signaling. A point worth noting is that as of the mid 1980s the alternate long-distance carriers can be accessed only by a tone telephone, whereas AT&T long distance can be accessed by either pulse or tone. It is likely that this limitation will gradually be phased out.

13.5 SUMMARY

How intimately the plant department is involved with the campus telephone system depends upon a myriad of factors. If the campus telephone system is furnished completely by the local regulated telephone company, then the plant department's involvement will probably be minimal. It will most likely consist of coordinating and overseeing outside plant and inside wiring activities of the local telephone company.

It will be quite another story if telephone operations are a responsibility of the plant department in the event that the institution has or is going to purchase its own telephone system. In this instance, the plant department in essence becomes the telephone company. Under these circumstances, the plant department will have to employ telephone craftspersons and telecommunications engineering staff. This is a situation for which few institutions are prepared. However, it is one that can greatly improve the institution's telecommunications services and capabilities while at the same time controlling the costs.

END NOTE

1. Foreign exchange lines provide a customer with local service in a distant location. The user leases one or more exchange lines in the distant exchange and the private lines to link the exchange lines with the local system.

PART V

PLANNING,
DESIGN &
CONSTRUCTION

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INTRODUCTION

Campus Development: From Plan to Product

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The development of the physical facilities of a college or university campus is an important factor in its ability to carry out its purpose and mission. This part of *Facilities Management* deals with the what and how of a campus' physical development. The planning steps outlined help preserve an institution's individuality while trying to use its financial resources most effectively.

The planning, design, and construction process can be as simple or as complex as the individual institution believes is necessary. Successful use of the principles will be achieved by following the various steps suggested in these chapters to the degree warranted by each project.

The chapters and their subject headings are organized to give the reader a sequential reference for information and guidance through the process of campus development. The authors emphasize the need for an academic plan to precede facilities planning and the importance of facilities that complement the academic needs of the campus. The procedural outline from campus and project planning to design and construction offers details to help the practitioner know the whats, hows, and proper order of campus development. The effectiveness of the process remains, to a large extent, dependent on the skill of the individual administrator leading the process.

The authors of these chapters are recognized professionals in the business of facilities development in postsecondary education and are experts in the field. They practice the professional advice contained in this text as they face the practical issues of implementing the procedures and guidelines they have outlined. These authors have learned it, lived it, refined it, and now pass their knowledge on so others might benefit and yet refine it further in its application to individual campuses.

CHAPTER 1

Campus Master Planning

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1.1 INTRODUCTION

The basis for all viable institutional planning efforts resides in the institution's mission, mandated by its governing board and defined by its academic and administrative planners. This same mission determines the number and type of academic programs, the delivery of which helps both to fulfill an institution's mission and to establish enrollment patterns. Master Campus Physical Plans are based on careful analyses of past and present patterns and on intelligent projections of future trends. The master plan coordinates campus program development and campus plant development, attempting to schedule incremental construction to coincide with predicted program change.

Experience has demonstrated that successful campus physical development is generally a project-by-project affair spread over many years. This kind of development requires some new construction and a considerable amount of reconstruction and remodeling. Time brings change, so progressive plans must be flexible. Few buildings constructed before World War II, for example, had mechanical cooling. Today's standards demand central heating and cooling with control systems for year-round temperature control. Building codes change, especially in regard to public safety and welfare. Existing structures must be brought into compliance with government mandates.

Rising energy costs dictate any number of cost-effective measures, and basic deterioration necessitates periodic overhaul and replacement. Short-range physical development decisions are often made on crisis schedules, which fail to use the strong planning policies embodied in the institution's master plan.

1.2 THE DECADE AHEAD

In the 1960s and 1970s, most campus planning centered around growing enrollments. The decade ahead, however, promises enrollment declines for most institutions, with stable enrollments or, at best, moderate growth. This decline has already begun and is reflected in increased institutional competitiveness in the student recruitment market. The competition has led to qualitative improvements on many campuses, because students are attracted to quality physical environments as well as quality academic programs. The immediate future suggests further changes.

Stable or Declining Traditional Student Enrollments

Demographic statistics clearly show that by 1990 the number of graduating high school seniors will decrease 25 percent nationwide. Since these students are already in school, this decrease is certain. What percentage of these graduates will continue in college is not so certain. In the '50s and '60s, most students knew that a college education meant added material benefits. The current outlook is not so simple, and many graduates doubt that a college degree is tantamount to certain financial success. Therefore, we can expect that the reduction in enrollments will at least equal the reduction in high school graduates, and many institutions will experience a net excess of facilities in relation to student clientele. This generalization will vary from institution to institution, depending on such factors as student financial assistance, the number and type of professional programs offered, and the overall prestige of the school (especially regarding its success in placing students in the job market).

Increase in Nontraditional Enrollments

Demographers forecast an increase in enrollments of older and other nontraditional students due to needs for career changes, for updating technological and professional knowledge, and for educational enrichment in retirement years. Older students will affect campus physical planning. Lighting levels, for example, which have been reduced in recent years for energy savings, may have to be increased for older students. More comfortable seating—and a concomitant lessening of classroom space—must also be considered. And all movement areas, especially from classroom to classroom, will present special considerations and requirements.

Developing Educational Technology

High technology is certainly here to stay. Campus plans will need to recognize the increasing popularity of computer science and related technologies, such as video disc and digital recordings. Alterations and renovations of existing facilities, as well as new construction, will be necessary as job-hungry students crowd technology curricula.

Upgrading Scientific Equipment

Computer technology and increasingly sophisticated electronic hardware have radically changed our ideas of state-of-the-art scientific equipment. Mechanical instrumentation purchased as late as the mid-1970s is now not only dated but in a different scientific era. The national deficit in updating college and university scientific equipment has been estimated as high as $4 billion to $6 billion. Obviously, upgrading teaching and research laboratories with state-of-the-art equipment will be a major capital expenditure in the next 10 to 15 years.

Maximum Utilization of Facilities

As costs related to space continue to escalate (heating, cooling, lighting, maintenance), effective utilization becomes increasingly important. Planning must include flexible assignment systems that permit timely reassignments and ready identification of excess facilities. Institutions will need to recognize the waste involved in concentrating classes in certain prime-time hours, allowing classrooms to stand empty during other hours. Reassignments will necessitate alterations, and frequent reassignments will encourage spatial designs that are multi-purpose. One notable exception is research laboratories, which are certain to become even more complex and specialized. Planners will need to remember that laboratories are not likely to lend themselves to ready reassignment.

Plant Aging

Extensive additions to facilities in the 1950s and 1960s are now approaching the major repair or replacement stage. Most built-up roofs have a life expectancy of 20 years; major mechanical systems have an expectancy of 25 years. In addition, upgrading older buildings was generally neglected in these boom years, and the need for reparations is, in some cases, acute.

Government Mandates

Since World War II, government building regulations pertaining to health, safety, and handicap accessibility have increased. Many existing facilities have not yet been brought into compliance with current regulations. Planners should not expect an ease in the flow of new, and more stringent, regulations.

Funding Limitations

Decreasing financial support is not a problem peculiar to higher education. All agencies and institutions dependent on public funds can expect the present tenuous financial situation to continue for several years. Campus physical planners must try to achieve maximum effectiveness and economy in the operation and maintenance of facilities. Cost reductions through increased energy efficiency are most promising. Many low-cost measures may already have been completed leaving only relatively expensive measures and, consequently, slower paybacks.

1.3 FOUR PHASES OF PLANNING CONSTRUCTION

Since campuses are subject to changes that make different physical development concepts possible, campus master plans must be revised periodically. Four distinct phases of planning and construction are needed in order to plan and implement a campus master plan. These phases are addressed in detail in this and following chapters.

Campus Master Planning

In the campus master planning phase relevant committees are organized and master plan responsibilities delineated. The basic physical elements of the master plan are identified and discussed by the committees. Policies and development strategies are set forth for incorporation into the campus master plan with the assistance of the campus physical planning consultant.

Project Planning and Programming

The project planning and programming phase includes the planning necessary to coordinate academic requirements and facilities requirements into a detailed listing of spaces and other physical facilities. This list will describe a specific project to be designed and constructed. After the project planning and programming phase is complete, individual project construction budgets can be developed.

Design Phase

The design phase includes selecting and contracting with a project design professional, the physical design of the project, and project bidding. (See Chapter 3, "Design Phase.")

Construction Phase

The construction phase includes contracting for construction, contract administration, project acceptance, insurance, and other construction-related matters. (See Chapter 4, "Construction Phase.")

1.4 CAMPUS MASTER PLANNING PHASE

Planning or "looking ahead" is an important and dynamic part of every college and university. The planning process is occurring in some fashion, controlled or uncontrolled, at all academic and administrative levels. There is a continuous process of review and evaluation, both formal and informal, which results in changes in teaching, research, and public service programs and ensures the effective accomplishment of an institution's missions and functions. Incremental physical development over time requires rethinking the campus master plan. From time to time, the changes are such that an institution must revise its planning efforts and produce new, comprehensive documents that will re-outline its future. The college or university that fails to design its planning activities carefully will not take full advantage of the effectiveness and efficiencies of coordinated academic and physical development. The planned campus will develop incrementally and will improve only when thoughtful consideration is given to existing facilities and proposed developments.

Academic and Physical Planning

Campus planning is divided into academic planning and physical planning. Most campuses have answered the most fundamental academic planning questions, so much of the physical planning process need not wait for the academic planning process to conclude. The physical planning process can occur nearly parallel with the academic planning process. The academic planning process must be finished, however, before the physical planning process can be completed.

1.5 ORGANIZING FOR PLANNING

Committees

Four committees provide the expertise and various viewpoints needed for a successful planning effort.

Campus Planning Steering Committee The chair of this committee should report directly to the institution's chief administrative officer and must devote the time and dedication required to provide strong leadership to the planning process. Committee members should include senior administrative officers, the chair of the academic planning committee, and the chairs of the student and faculty senates. The responsibility of this committee is to see that appropriate timetables are established and met, that interaction between committees occurs, and that all aspects of the planning process proceed expeditiously.

This committee should have clerical staff support and should make periodic progress reports about the planning project to the campus community.

Academic Planning Committee The chair of this committee should report to the vice president or head of academic affairs. Committee members should include academic deans, faculty, and student leadership. The responsibility of this committee is to prepare market studies that will indicate growth potentials and nongrowth areas for individual academic disciplines. Studies should also be prepared dealing with special institutional strengths or thrusts, library development, special policy matters, and other issues influencing or affecting the educational process. Realistic enrollment projections by academic discipline should also be prepared.

This committee should be supported with clerical and planning staff. The principal planner should be a carefully selected member of the faculty who is given released time to work on the project. The committee should have the authority to hire special consultants when necessary.

Committee on Student Life The chair of this committee should report to the dean of students. Committee members should include student body leadership, a faculty representative, and a high-ranking campus administrative officer. The responsibility of this committee is to inventory, examine, and assess student facilities relative to student study, social, recreational, athletic, and health-related needs.

This committee should be supported with clerical staff and a mid-level administrator appointed by the dean of students. The administrator prepares data and reports relating to committee responsibilities.

Campus Physical Planning Committee The chair of this committee should report to the chief financial officer of the institution. Committee members should include the director of facilities and appointed students, faculty, and staff. This committee makes an inventory and assessment of existing facilities relative to current and future needs. The committee also proposes the policy framework and design guidelines for future campus improvements.

The Physical Planning Committee should be supported with clerical staff and with a senior member of the institution's physical planning staff. He or she will prepare data, reports, and drawings for committee deliberation. The committee should have authority to secure special consultants when necessary.

At most institutions it would be appropriate for the director of physical plant to provide a leadership role in preparing materials for the Physical Planning Committee. The plant director is usually a key figure in preparing the physical development plan. The plant office is the primary source of drawings and information relating to existing facilities. In addition, the plant office usually has the ongoing responsibility for campus physical enhancement through construction of capital projects, through remodeling to meet changing academic needs, and through its maintenance program. The plant office also has contact with local government officials with responsibilities that relate to the physical planning process, for example, transportation planning, utility planning, and zoning.

Physical Planning Consultant

Essential to the planning process is an experienced campus physical planning consultant. The consultant should be given a program—essentially the result of committee deliberations—that has been reviewed and approved by the institution's administration. This program will be the basis for the physical development plan narrative, drawings, and models. The consultant will add the perspective of a design professional who has similar planning experiences with other institutions. This professional experience should maximize campus functions and aesthetic quality.

Postsecondary education officials must recognize that physical improvement decisions are long-term, 50 years or more. A qualified consultant can help foster long-term decisions without the pressures of campus politics. The consultant should be chosen by the institution through a competitive .selection process as outlined in Chapter 3, "Design Phase."

Chief Administrative Officer

The institution's president (or chief administrative officer) must be active in the planning process and must involve other senior administrative staff. The planning issues (both academic and physical) are policy oriented. The president must be the prime motivator of the process, must establish the organization for planning, and must give generously of his or her time to stimulate and influence decision making. Senior administrative officers should keep current with the progress of the four planning committees through their reports. The senior administrative officers also report regularly to the president.

Committee decisions that could put the president in an unfavorable political position should be addressed during early discussions rather than after committee work has concluded. The institution's governing body will hold the president responsible for the quality of the final plan.

1.6 ELEMENTS OF THE PHYSICAL PLAN

General

Administrators have decided to update the institution's campus plan, have established the various committees, and assigned people to be responsible for and involved in the planning process. Then a schedule is developed to consider the elements that need to be incorporated into the campus physical plan. The physical planning elements vary from campus to campus. The relative importance of one element over another also varies from one institution to another. Each element should be investigated. Existing conditions and policies should be evaluated and mid- and long-range plans and policies formulated for the physical planning consultant's use and for inclusion in the final planning document.

Many of the planning elements can be assigned to special interest groups on campus. These groups will report their progress and conclusions to the Campus Physical Planning Committee. Other planning elements may be assigned to special consultants whose reports should also be reviewed by the committee.

The institution's facilities planning section should prepare a comprehensive list of space assigned to each academic program or discipline and compare that amount of space to the amount of space the program would generate if reasonable space allocation standards were applied. The committee as well as representatives of the academic programs should review this space assessment and the standards used. Based upon enrollment projections for academic disciplines, the standards can be used to determine the relative need and priority for new or remodeled space.

Space Planning Standards

Space standards for each type of space and academic program should be developed through a realistic assessment of the amount and type of square feet needed for the various academic, academic support, and noninstructional functions.

For example a classroom space standard might be developed as follows:

$$\text{NASF/WSH} = \frac{\text{NASF/Student Station}}{\text{Hrs/Week} \times \text{Percent Station Occupied}}$$

Net Assignable Square Feet (NASF)—Amount of usable floor space (excluding corridors, mechanical rooms, etc.) within a given structure or space.
Student Station—The space and furniture to accommodate one student.
Hrs/Week—The number of hours during an average week that the room is occupied by a regularly scheduled class.
Percent Station Occupied—When room is in use, the percent of the total number of student stations in the room that are occupied.

If a classroom has 540 net assignable square feet (NASF) and 30 student stations, the NASF per student station would be 18. And if the room were scheduled for instruction 30 hours per week with an average of 21 of the 30 stations occupied (70 percent usage) then –

$$.857\ (\text{NASF/WSH}) = \frac{18\ \text{sq. ft./station}}{30\ \text{hrs. per week} \times .70\ \text{station utilization}}$$

Classroom Space Standard = .857 NASF/WSH

Care must be exercised in determining a space standard. Consideration must be given to the amount of space required for graduate study as opposed to undergraduate study, small-enrollment courses versus large-enrollment courses, institutions with large evening enrollments where fewer hours are available to teach within a given number of spaces, and other factors.

Space standards for offices can also be established, for example—

Faculty Offices	100-120 NASF
Deans or Directors	150-200 NASF
Vice presidents	200-300 NASF

Space standards for teaching and nonteaching (research) laboratories are more difficult to determine. An assessment must be made of each academic program's needs. History or literature classes will probably not require any laboratory space. Sculpture, biology, nursing, and other programs will require considerable laboratory space.

Standards can also be determined for library space, archive and storage space, study space, student recreational space, and other space. University and college facility planners and planning consultants are usually familiar with planning standards and factors that are necessary in projecting or evaluating the amount and type of space required to meet institutional needs.[1]

Planning Elements

This list of planning elements is intended to be a general guide for campus physical planning at most institutions of postsecondary education. Certain elements will not apply to some campuses, and certain elements will be missing for other campuses.

Existing Instructional Facilities

- The amount, type, and condition of space allocated to each academic discipline.
- The amount, type, and condition of space allocated for library and museum purposes.
- Important functional relationships between academic and other building areas.
- Spatial and functional relationships that deserve special attention between existing building areas, plazas or outside open areas, recreational areas, study areas, extracurricular student life centers, parking areas, and service areas.
- Buildings that could or should be adapted for different uses.
- Building accessibility to the handicapped.

Institutional Support and Student Services

- The amount, type, and condition of space allocated for extracurricular student life.
- The amount, type, and condition of space allocated to all administrative and support functions.

Housing

- Type and quantity of units.
- Condition of units.
- Future expansion.
- Buildings to be razed or adapted to new uses.

Sport and Recreational Facilities

- Adequacy of existing facilities.
- The amount and type of space allocated.
- Readaptive uses of existing facilities.
- Future expansion.

Vehicular and Pedestrian Circulation and Parking

- Major and minor roadways in the community serving the campus.
- Major and minor on-campus roadways.
- Campus service and emergency access drives.
- Parking areas including short-term, long-term, handicap parking, loading areas.
- Bicycle paths.
- Vehicular safety and signage.
- Pedestrian safety and signage.
- Mass transit facilities.

Land Use and Site Planning

- Functional relationships between campus building areas, plaza areas, parking service areas, centers for students, and recreational areas.
- Important spatial relationships.
- Areas that should be set aside for future building and other land uses.
- Areas not presently a part of the campus that should be considered for purchase or sale.
- Areas of special interest or importance that should be preserved or protected.
- Adequacy of campus outdoor lighting by functional area.

Utilities

- Size, condition, and reserve capability of water service (including fire hydrants), sanitary sewers and treatment facilities, storm sewers, natural gas lines, the campus utility system, and the steam distribution system.
- The campus telephone system.
- Fuel storage (liquid and/or coal).
- Alternative fuel and power options.
- Energy management and innovations.

Landscape

- The pattern and function of walkways.
- The type and quantity of trees and shrubs.
- Campus flower beds.
- Campus features including plaza areas, ponds, significant views or vistas, and open spaces.

Visual, Spatial, and Other Elements

- Color and type of campus building materials.
- Architectural style.
- Screening and eliminating undesirable visual elements.
- Campus graphics and public information.
- Campus art work.

Multi-Year Plan

The multi-year or mid-range plan is sometimes used to identify, describe, and budget for a five- to ten-year implementation program. For this purpose a target year is identified for completion of all physical improvements. Each year is then further detailed with development increments. Five-year (or more) capital improvement plans are required in some states before a single-year capital budget is considered for funding. In order to develop a multi-year plan, the combined outputs of academic, fiscal, and physical planning are needed. In sequence, fiscal planning is based on physical planning, and physical planning is based on academic planning.

1.7 APPROVAL PROCESS

As with any plan that has a long-term effect on a large number of people, the approval process for campus planning should be carefully considered. Each phase of the planning process will be reviewed by the committees involved and by those to whom the committees report. A draft of the plan should be distributed to a wide constituency. This step should allow rigorous objections to be heard before the plan is printed in final form. Distribution should include faculty, staff, students, and members of the community outside the campus affected by such a plan. If the campus has an urban setting, people from the surrounding neighborhoods, elected officials, representatives of local businesses, and safety and security forces should have the opportunity to review the plan and offer suggestions. The final official document should reflect consideration of all these interests. In addition, most systems require approval by one governing board committee and/or the total board.

An effective campus master planning process will result in more than a slick, printed document. The process should produce a commitment from the campus leadership to the physical development principles in the plan. The planning process may even result in higher priorities for physical plant funding needs and increased funding.

END NOTE

1. For additional information regarding developing space standards, see Harlan P. Bareither and Jerry L. Schellinger, *University Space Planning* (Urbana, Chicago, London: University of Illinois Press, 1968); and State of Illinois Board of Higher Education, *Comprehensive Study of Space Planning Standards* (State of Illinois, 1972).

CHAPTER 2

Project Planning and Programming

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2.1 ACADEMIC PLANNING

The first step in the planning and programming process at an institution of postsecondary education is academic planning. The academic planning necessary at this phase is usually done during a different period than the academic planning needed for Campus Master Planning. Academic planning for project planning and programming addresses the institution's mission within the higher education community and relates that mission to individual project definitions and justifications.

The academic planning required for specific physical development projects is based upon, but not limited to, the following factors:

- Existing and anticipated enrollment for each academic discipline to be located in the project.
- Market evaluations and projections for future demands in the various disciplines.
- Demographic projections that will affect enrollment and academic programs.
- In-depth reviews of existing and new programs.
- An analysis of programs offered by neighboring institutions, which could or should affect programs on the campus.

The proper compilation and review of the above is used to determine the quantity and quality of space needed to achieve the actual operation or program requirements. This information is used not only to determine interior space use but also for outdoor space such as parks, playgrounds, and parking areas. In general, the academic plan reflects the image the institution wants to establish with the surrounding community.

Academic planning must be of sufficient projection, usually five to ten years. A 10-year projection of need is often used as a base for project planning and programming. Even a 10-year plan is relatively short compared to the 50-year life-span of the completed building.

2.2 FACILITY PLANNING

Fulfillment of the academic plan is accomplished by creating a physical environment conducive to the goals of postsecondary education and the individual institution. Once the long-range academic goals of the institution are defined, prioritized, and programmed, it is possible to create individual physical development projects that address such things as space needs for expanding academic disciplines, specific outdoor areas of the campus, parking and traffic problems.

2.3 PROJECT PROGRAMMING

In order to synthesize the academic and facilities plans, resource professionals prepare a program statement and gather cost estimates.

Resource Professionals

The planning process for any project requires a professionally qualified leader. This can be a member of the campus planning staff, the plant department, a consulting architect or engineer, or an otherwise qualified planner. Other resource professionals or consultants should be used to provide needed specialized information and recommendations.

Program Statement

The program statement is a written description of the proposed physical development project. The more detail and clarity it has, the easier it will be for the project designer to translate the description accurately into a building or facility design. A great deal of effort should be spent on developing the program statement. In the case of a new building or a remodeling project the program statement should include a room-by-room square footage listing of what the institution expects to be designed into the project. The program statement should include diagrams depicting the functional relationship of one programmed area to another. It should also list specific building requirements, such as plumbing, heating and air conditioning, electrical, and a list of all major items of equipment that will eventually be located in the building. The more detailed the program statement is, the fewer surprises that will turn up later.

The facility planner develops the program with a project committee composed of people who will use and/or be responsible for the project when it is completed. This group will define the purpose, scope, and nature of the project and required elements (offices; classrooms; laboratories; reception and lounge areas; special support spaces, such as animal holding areas or computer spaces). The facility planner will use space planning standards to justify the projected academic needs (see Chapter 1, "Campus Master Planning."). The committee of users will detail the specific space requirements and will make functional relationship determinations. This precise description of the project should be included in the program statement.

Estimates

A project estimate, by definition, includes all costs pertaining to the completion of a project (see Appendix 2-A). This differs from a construction estimate, which is limited to the construction portion of the project.

The project estimates, prepared during the planning phase and included in the program statement, are usually based on a cost per square foot. This cost is figured after the program is translated into the number of gross square feet needed for the project. When making the initial project cost estimate, it is important to know on which fiscal year the estimate is based. The estimates must be updated to the year the project is finally approved for construction, so the project can be built within the actual budget allocation.

When a project architect is selected, it is important to confirm that the project budget estimate is realistic for the proposed project. As the architect develops the design, he or she will also develop a detailed project estimate giving a further breakdown of the elements of the project to replace the cost-per-square-foot calculation used for the initial project estimate.

2.4 CLASSIFICATION OF FACILITIES PROJECTS

A wide variety of terms have come into use to describe facilities projects. Many are duplicative, others are used interchangeably. Few have been given clear definitions. There is no need for an exhaustive list of definitions pertaining to facilities simply to gain uniformity of terminology. But clear and distinctive classifications of projects are needed for the formulation of programs, their funding, design, and construction. Classifications should be commensurate with those of other professions to the maximum extent possible. They should be long-lasting and easily applied, and should not depend upon changing values such as cost, which would require an estimate in order to determine the classification.

The following five classifications have been established for this discussion and focus on the purpose of the project.

Maintenance

Maintenance is the recurrent, day-to-day, periodic or scheduled work required to preserve or immediately restore a facility to such condition that it can be effectively used for its designed purpose. It includes work done to prevent damage to a facility that would be more costly to restore once damage took place (see Part III Maintenance Management).

Repair

Repair is the restoration of a facility to such condition that it may be effectively utilized for its designated purpose. The repair is done by overhaul or replacement of major constituent parts that have deteriorated by action of the elements or usage. The deterioration has not been corrected through maintenance. Replacing roofs, tuckpointing buildings, and replacing air conditioning compressors are examples of repairs.

Renovation

Renovation is the total or partial upgrading of a facility to higher standards of quality or efficiency than originally existed. New installations of air conditioning, installation of grid ceilings with recessed fluorescent lighting to replace suspended incandescent lighting, and enclosing stairwells to comply with current fire safety codes are examples.

Alteration

Alterations change the internal arrangement or other physical characteristics of an existing facility so that it may be effectively used for its designated purpose. Examples are partitioning a classroom into offices, or converting a room to laboratory use by installing laboratory benches and fume hoods.

New Construction

New construction is the erection of a new facility or the addition, expansion, or extension of an existing facility that adds to the building's overall external dimensions. New construction projects range in size from major new buildings to extensions of sidewalks.

Distinguishing Between Classifications

Classification of projects should be oriented toward the project's objectives in order to avoid duplication and confusion. Fund requests, and the justification offered in support of the requests, are based on the purpose for which the funds will be used. Following are examples of classifications:

- The replacement of a roof due to deterioration is a *repair* project, even if the project includes upgrading the roof by adding insulation or installing a new type roof. The *purpose* of the project in this case is the replacement of a deteriorated roof.
- The replacement of a roof in good condition in order to add insulation is a *renovation* project. The *purpose* of the project is to improve the energy efficiency of the building.

- The installation of a grid ceiling with recessed fluorescent lighting in a classroom to improve the general appearance and acoustics is a *renovation* project. But the partitioning of a classroom into offices is an *alteration* project, even though lighting and air conditioning improvements may be included, since the objective is to change the internal arrangement.
- A project to provide handicapped accessibility to an ongoing program, necessitated by Section 504 of the Rehabilitation Act, is classified as a *renovation* project. A similar project to provide handicapped accessibility to an existing facility, brought about by assignment of an existing program to the facility, is an *alteration*. The requirement in the first case came about from governmental mandate, while the requirement in the second case resulted from a decision made by the institution. (The cost of providing accessibility should have been considered in making the decision.)
- In rare cases there may not be a single dominant objective. An older building may be completely renovated to modern standards and, at the same time, altered for changed functional use. A combination type classification may be appropriate to describe the project, in this case alteration/renovation.

2.5 CHARACTERISTICS AND FUNDING PROJECTS

The procedures for identifying, prioritizing, and funding the foregoing five classifications of projects vary between public and private institutions and among states. Following are those features considered generally common to each classification except maintenance, which is covered in Part III, Maintenance Management.

Repairs

Repair projects accomplish the timely replacement or overhaul of major building components to achieve one of three goals:

- Prevent further damage that would occur if repairs are delayed.
- Ensure the continued safe use of the facility.
- Provide that the facility can continue to be effectively used for its assigned functions, with minimum interruptions, through routine operation and maintenance effort and cost.

Repair projects are normally funded as part of an annual capital appropriation or allocation. Individual projects may be funded in one of two ways, depending upon their cost:

- The appropriation or allocation of a specific amount to an individual project, normally a line item project in the budget. The funding is fixed in both amount and purpose.
- An allocation of a specific amount for an itemized list of projects.The total allocation is for designated projects, although the cost of each project may vary from the estimate.

The flexibility an institution has for diverting these funds to other repair requirements, which develop subsequent to the appropriation or allocation, varies. Funding authorities normally require a report on actual use of the funds. To maintain credibility there should be a close correlation between the program as funded and as accomplished.

The repair program, sometimes known by such titles as Preservation or Repair and Replacement, is regularly a part of the annual budget request of the institution. The program includes the following information on each project:

- Project identification.
- Project cost estimates.
- A summary description of the need (justification).
- Relative priority of each project.

While the institution determines the priority of the total repair program, the plant department has singular responsibility and authority for its formulation. Various procedures are used for the formulation of the program of repair requirements. In the past, it was frequently done through a single annual effort during the annual budget development. With the trend in recent years to detailed justification of fund requests, more emphasis must be given to maintaining an up-to-date itemization of individual repair requirements. This requires (1) a thorough facilities inventory to identify the backlog of requirements and to project future requirements, and (2) a system for regular inspections to verify projected requirements and identify new requirements.

Computerization of repair requirements facilitates the formulation of an annual budget request. Once a comprehensive computerized repair program has been established, new projects can be added to the programs as identified and funded. A report of current requirements can be obtained at any time.

Renovations

Renovation projects are concerned with the quality of a facility, not with its suitability for a specific purpose. These projects correct or improve one or more of the following:

- The general condition of the facility with regard to modern standards of quality. Included are the installation of HVAC systems and improved lighting, acoustics, floor coverings, and general appearance.
- Compliance with current codes and standards, including fire safety and accessibility.
- Upgrading for improved operating and maintenance efficiencies, including energy efficiency.
- The addition of new or improved teaching and research equipment without change in functional use.

Renovation projects may be funded by capital appropriations or allocations, or by locally available funds. Those projects needed to comply with changed codes and standards, to improve operating and maintenance efficiencies, and major projects to improve the general quality of all or a major portion of a building, are funded through an annual capital program. Improvements in the general quality of limited areas, such as improved lighting or the addition of carpeting, may be funded from locally available operating funds—not from plant operation and maintenance funds. Funds may also be received from private donors, particularly for projects to upgrade older facilities and provide for their continued use.

The plant department is responsible for identifying projects needed to comply with codes and standards and projects to improve operating and maintenance efficiencies. The facilities department is responsible for the engineering evaluations, cost estimates for upgrading older facilities, and installation of new equipment. This latter function will normally be in close coordination with academic officials, since new equipment needs are influenced by functional use, including planned future use, of the facility.

Renovation projects should always be evaluated for increased operating and maintenance costs that may result.

Renovation requirements may be funded as line items in the capital budget, or, like repairs, through an allocation of an amount for a specific list of projects. The institution will prioritize the individual renovation projects and the total renovation program relative to other requirements. Renovations generally have a lower priority than repair requirements.

Alterations

Alteration projects are concerned with the suitability of a facility for its assigned use. They are normally brought about by one of the following developments:

- Changes in the assigned functional use of facilities.
- Major changes in the teaching and research methods or equipment, which require changes in the interior arrangement of the

facility. Examples are adaptation of an existing classroom to a computer training facility as part of a discipline and installation of study carrels with audio equipment for foreign language study.

Alteration projects may be funded by capital appropriations in response to specific requests or from locally available funds.

In alteration project planning, the physical plant department provides engineering evaluations and cost estimates. As with renovation projects, the possible increase in operating and maintenance costs should be considered. Alteration projects are the primary concern of the academic, or institutional planning, officials.

Alteration projects must be integrated into a relative priority list with all the institution's fund requirements. Alterations must be recognized as a separate requirement, especially distinguished from repairs.

New Construction

New construction fulfills one of the following needs:

- A facility has become inadequate through deterioration or obsolescence and cannot be renovated economically.
- The requirements can be most effectively and economically met by new construction.
- To meet new requirements, such as increased enrollment.

The physical plant department must be included in the early comparative evaluations of the adaptations of existing facilities versus new construction. The added operating and maintenance costs of both new and renovated/altered existing facilities must be considered in the evaluations that are made by in-house engineers or contracted consultants.

2.6 DESIGN AND CONSTRUCTION METHODS—GENERAL CONSIDERATIONS

Once a project is funded, administrators must determine the best methods of accomplishing the design and construction phases. Following are the principal considerations in choosing in-house or contracted designers, and in-house crews or contractors for construction.

Size of Project

Many institutions are limited in the dollar value of projects done in-house. These limitations may be established by the institution or by state regulatory agencies and range from $5,000 to $50,000. Some institutions have no limitation.

Complexity of Project

With the advent of the elevator in 1875, construction design has become more complicated. New engineering techniques for rigid framed steel buildings, air conditioning, acoustical engineering, a vast vocabulary of construction materials and construction methods, laws regulating the construction process, rising costs of construction and maintenance, and changes in construction techniques and tools have all contributed to the complexity. Administrators must be certain that either the staff or the consultant has the capability to manage complex design and construction requirements.

In-house Construction Capability

Part of the remuneration of physical plant tradesmen is often in the form of retirement and other benefits accruing to institutional employees. Crews on repair, renovation, alteration, and new construction projects are normally on a charge-back system, paid from the project funding. Crews are sized, as much as possible, for continuous employment. In-house construction capability is limited to that for which a need can be foreseen, and cannot change appreciably from year to year. This will limit the ability to handle special appropriations without short-term hirings and terminations.

The most compelling justification for accomplishing projects with in-house crews occurs when close coordination of construction with continued use of the building is required. Plant departments can vary the construction schedule and methods to meet the continued usage requirements of the occupants. Although this will increase the cost of the project, the increase will normally not be as great for the plant department as for outside contractors.

Deadline Requirement

The preparation of drawings and specifications for competitive bidding, the bidding process, and notice-to-proceed time given to contractors all take time. Projects sometimes arise that must be completed within a limited time. A research grant may require a facility alteration beyond the normal limit of physical plant work projects, but which can be completed within available time only by physical plant staff.

2.7 FROM PLANNING AND PROGRAMMING TO DESIGN AND CONSTRUCTION

The task of planning and programming an individual project is an internal decision-making struggle. Within the college or university a project must be planned, analyzed, and described by facility planners, project users, maintenance professionals, and institutional policy makers. The project must be planned, analyzed, and described by facility planners, project users, maintenance professionals, and institutional policy makers. The project must be planned within budget constraints, while meeting academic and academic support program requirements. The final product is an approved compilation of decisions and compromises that can be given to design and construction professionals. After the project architect or engineer receives the program statement, the planning and programming function shifts into monitoring plans and specifications to ensure that they meet stated program needs.

Appendix 2-A

Project Cost Estimate

Project: ____________________ Date: ____________

Account Code: ______________ By: ______________

Project Development

603. Relocation & Renovation $ ________
604. Programming $ ________
605. Cost Control $ ________

Sub-total $ ________

Site Preparation

610. Alterations $ ________
611. Surveys $ ________
612. Demolition $ ________
613. Test Borings $ ________

Sub-total $ ________

Construction (New Building or Remodeling.)

614. Utilities to Site $ ________
620. Construction Cost $ ________
621. Nonstructural Improvement $ ________
622. Landscaping $ ________
623. Fixed Equipment $ ________
624. Special Fixed Equipment $ ________
625. Parking Area $ ________
626. Street and Sidewalk (Repair) $ ________
627. Other (Specify) $ ________

Sub-total $ ________

Bidding Contingency

628. @ 7% of 620 thru 628 $ ________

Construction Contingency

629. @ 3% of 620 thru 628 $ ________

Fees

650. Architects @ x% of 620 thru 628 $ ________
651. Architects Cont. @ x% of 629 $ ________
652. Engineer $ ________
653. Landscape Architect $ ________
654. Interior Design $ ________

Sub-total $ ________

Legal and Administrative

661. Interest $________

662. Legal $________

663. Construction Administration $________

Sub-total $________

Miscellaneous

666. Moving $________

667. Government Field Expense $________

668. Other Cost (Specify) $________

Sub-total $________

General Contingency

669. @______% $________

Movable Equipment & Furnishings

631. Movable Technical & Scientific Equipment $________

670-689. Furniture $________

Sub-total $________

TOTAL ESTIMATED CAPITAL COST $________

CHAPTER 3

Design Phase

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3.1 INTRODUCTION

During the design phase of a facilities project, the need, as described in the planning and program data, is translated into a set of detailed plans and specifications or contract documents. The planning and program phases of a total project provide the design team with a starting point. If the institution inadequately defines the need and goals of the project—in other words, fails to define the problem to be solved—the completed design and construction efforts may not successfully fulfill the needs and expectations of users.

3.2 THE DESIGN TEAM

The plans and specifications may be prepared in-house by the institution's architectural and engineering (A&E) staff or by A&E consultants. There may be a combination of in-house engineering and a consulting architect, or other mixes of staff and consultants to form a successful design team.

3.3 BASIC INFORMATION NEEDED FOR DESIGN

Record Drawings

All existing buildings and utility distribution systems should be accurately detailed in reproducible plans. Accurate information that may be a consideration in the new design must be provided for existing facilities. Plans and descriptive material of existing buildings, mechanical and electrical systems, and underground or overhead utility systems should be up-to-date. Current information is needed for new design situations and as part of a good facilities management program. It is often necessary to verify record drawings because of possible changes made since the drawings were prepared.

Institutional Standards or Guidelines

The institution should prepare written or graphic standards to help establish the square footage floor areas allowed various functions. Figure 3-1 provides an example of area standards. Guidelines also serve in the standardization of mechanical and electrical materials, plumbing fixtures, and other equipment and material. Standardization will minimize the number of different manufacturers of components and make it simpler to train the maintenance staff. These guidelines should be given to the design team.

The construction materials used in building exteriors, the style of architecture and planned siting for the institutional buildings, pavement, walks, and parking areas should be included in institutional guidelines. Site lighting and exterior and interior signage graphics are also matters for standardization. If a master development plan is available, it may already contain much of the guideline information.

Figure 3-1

Standard Floor Areas

Office	Office Sq. Ft.
College Dean	300-375
Dean/Chairman/Director	190-230
Associate Dean or Equivalent Position	170-200
Department Head	170-200
Other Admin. Officers Assoc./Asst. Directors Asst. Deans, etc.	120
Exec. Secretary & Reception Space	180
One Secretary—Chairman, Director, Department Head	150
Two Secretaries—Department Head	200
Three or More Secretaries in One Area	80 ea.
Faculty Office, Single	110-120
Faculty Office, Double	170-200
Graduate Teaching Assistant	60-75 (cubicle space)

Energy Consumption Guidelines

The institution should establish consumption guidelines for the design team. The energy guidelines should contain consumption limits in terms of BTUs per square foot per year, as well as performance criteria for lighting and mechanical equipment.

Policy and Procedure for Selecting A&Es

There is a possibility for controversy in the selection of consultants for professional services because judgment is involved. The selection of architectural and engineering consultants requires judgment based on the best available information. There must be no hint of favoritism or improper influence in the selection process.

Before beginning the selection process, remember that bidding for professional services does not serve the institution's best interests. Bidding is applicable only when the service to be performed can be precisely specified, for example, a painting contract. Professional engineering and architectural services, on the other hand, are dependent upon the imagination and talent of the individuals providing the service. These qualities are not amenable to the bidding process. The best architect or engineer for the problem at hand may not be a product of a low bid. The process involves two steps: (1) selection of a consultant, and (2) negotiation of a fee. The policy of the institution for selecting A&E consultants should allow for use of a variety of capable firms. The policy should include the capability to choose a firm simply and quickly for small projects, as well as a procedure for committee review and selection for larger projects. For an example policy statement and procedures, see Appendix 3-A.

In some states, a central construction agency may have firmly established laws, rules, and regulations concerning the selection of architectural and engineering firms. This central agency may also be in charge of the task of selection. In these states, the institution may have little direct responsibility in the process but should be involved at each step.

Information File on Available A&E Firms

In order to form a design team involving consultants, the physical facilities staff should keep a current file of firms interested in doing work at the institution. A form similar to Government Services Administration form 254 may be used for this purpose. When a project is contemplated, this file can be reviewed for potential consultants. A sample form is enclosed in Appendix 3-B.

3.4 SELECTION OF A&E CONSULTANTS

Procedure

The procedure for selecting architectural and engineering consultants should be in writing. These elements should be included in the selection process:

- Preparation of planning and program data and budget limits.
- Appointment of an appropriate selection committee, for large projects.
- Selection of a list of firms by the facilities administrator after researching available information.
- Selection of a few consultants for interviews. A screening committee is sometimes formed to select a slate to be interviewed by the selection committee. This gives greater objectivity to the selection process.
- Interview of chosen firms by the selection committee.
- Ranking of interviewed firms.
- Negotiation of a fee by an appropriate administrator, such as the facilities administrator, with the first-ranked firm. If negotiation of a satisfactory fee is not possible, negotiations are conducted with the second-ranked firm.

Interview and Fee Negotiation

The American Consulting Engineers Council (ACEC) has published *A Guide to the Procurement of Architectural and Engineering Services.*[1] The guide provides practical information on points to be covered during the interview process. The ACEC guidelines list the following criteria for evaluating and ranking the firms interviewed:

1. The education, experience, and expertise of the firm's principals and key employees.
2. The firm's general experience, stability, and history of performance on projects similar to the one under consideration.
3. Availability of adequate personnel, equipment, and facilities to do the needed work expeditiously.
4. The name, or names, of individuals in the firm who will be assigned key project responsibilities, with particular attention to their qualifications, competence, and past performance.
5. The firm's approach to planning, organizing, and managing the project effort, including communication procedures, approach to problem solving, data gathering methods, and evaluation techniques.

6. Facilities and equipment owned by the firm including computer capability, reproduction and communication equipment, or other specialized equipment applicable to the project under consideration.
7. Present workload with attention to current and future commitments of available personnel—particularly those key persons expected to be assigned to your project.
8. Financial stability, with special attention to avoiding a situation in which the firm is solely dependent upon income from the project at hand for its existence.
9. Recommendations and opinions from each firm's previous clients as to its ability to meet deadlines and remain within budget. Prior clients may also be able to advise you as to a firm's sense of responsibility; attitudes of key personnel; concern for economy, efficiency, and environment; and quality of service.
10. On-site examination. If possible, observe each firm's facility and current and/or completed projects.
11. Proximity of the engineering firm to the proposed project site and/or the plant administration's office.
12. The reputation and integrity of the firm within the profession and the community.
13. Awards received by the firm and technical papers authored by employees.
14. Special considerations for some projects might include staff conversant in foreign languages and qualified minority representation.

Negotiation of a fee with the first-ranked firm should follow submission of a comprehensive proposal by the firm. The comprehensive proposal should include the project scope, work schedules, contract language proposals, and a proposed fee. The fee may be an agreed percent of the construction cost; a fixed fee; or an hourly cost, paid at agreed hourly rates for each type of person used on the design.

Fixed Fee Negotiations

This type of negotiation may seem difficult to develop. The American Institute of Architects (AIA) has published *Compensation Guidelines for Architectural and Engineering Services.*[2] These guidelines are used by architects and engineers to estimate the fixed fee appropriate for a contract. The process involves the need to identify the services to be performed in detail and to calculate the compensation required for the services rendered. In other words, the fee is cost based. A fixed fee, which is based on consulting costs, is preferred to a fee based on the percent of construction costs. A fee based on a percentage creates an incongruity. The owner is interested in lower construction costs, but the consultant, a member of the owner's team, is paid a greater fee for higher construction costs. With a fixed fee, the interests and aims of the consultant are centered with the interests of the owner. However, any changes in program or scope of the project will usually be followed by a request for an additional fee to cover the extra work.

In developing the terms of an A&E contract, consideration should be given to the contents and coverage of the standard architectural and engineering contract. In many instances modifications to a standard contract are needed, or perhaps a new contract form should be developed by the institution. There are at least two special aspects to be considered.

In a standard arrangement the consulting engineers are under contract to the architect, who in turn collects the entire fee under contract to the institution. The architect then pays the consulting engineer a fee. The fee paid the consulting architect may or may not be sufficient to cover on-site inspection adequately. The proper installation and check-out of new mechanical and electrical systems requires frequent site inspections by the engineering firm and appropriate members of the plant staff. The institution should be sure that inspection time is included in the A&E contract.

It may be desirable in some cases to contract separately with the engineering consultants. This is particularly true if a special expertise, such as acoustic consultants, is needed. A separate contract not only obtains the on-site time needed, but enables the consultants to better serve the institution's—their client's—best interests. When the architect is the "client" hiring the engineer, the architect's interests may vary from the institution's. For projects that are primarily mechanical or electrical work, it is appropriate to have an engineer be the primary contractor.

Another special consideration is the agreement covering redesign if the bids exceed the construction budget by a reasonable amount. The agreement should stipulate that the A&E firm will redesign to bring the project within budget, at no additional fee.

3.5 RANGE OF A&E SERVICES

The complete range of services from architectural and engineering consultants covers the following:

Pre-Design Services

These services include programming, space studies, existing facilities surveys, feasibility studies, and budgeting. When pre-design services are required because the institution has not completed the programming documentation, a separate fee is agreed upon in order that the actual design fee is not inflated by pre-design costs. A separate pre-design fee eliminates questions of propriety about the design fee.

Site Analysis Services

Site utilization studies, on-site and off-site utility studies, environmental studies and reports, and zoning assistance are part of site analysis. These are not normally part of design and may be covered in the pre-design fee.

Schematic Design Services

With this service consultants provide drawings and other documents showing the general scope and relationships of components for owner approval. While the design at this point is conceptual, sufficient detail is developed for architectural, structural, mechanical, electrical, civil, and landscape elements to permit preliminary evaluation of possible problems associated with local planning and code review agencies.

Design Development Services

At this stage the character of the entire project is fixed. The design development stage is one of the most important milestones in the process. Upon completion of the design development plans, the project committee, administrators, and A&E consultants will have developed—

- Type and size of each room.
- Location of each room and the utility services for each room.
- Furniture and equipment to be used.
- Construction materials for the facility.
- Detailed cost estimate.
- Life-cycle cost analysis.
- Aesthetic characteristics of the facility.

At this stage the design is complete and following stages establish details needed for construction.

Construction Documents/Final Plans Services

The details needed for bidding, and subsequently for construction, are completed at this stage. When the construction documents are 90 percent complete, a final estimate of construction cost is prepared before bidding.

Bidding Services

Consultants assist the owner in obtaining bids and in awarding contracts for construction. Responses are made to questions from bidders, and alternates or substitutions are analyzed. The A&E firm assists in preparing the contract documents.

Construction Contract Administration Services

These services include review of shop drawings, on-site observation of work in progress, and coordination of construction inspection. The institution and/or the state may have its own inspection staff to help assure the quality of the work, or it may rely entirely on consultants for this service.

3.6 INSTITUTIONAL REVIEW AND APPROVAL PROCESS

At the various stages of design, the facilities administrator coordinates review of the presented design documents. One way to ensure opportunity for review is to require principal administrators to sign off on the plans. In these reviews—which take place at Schematic Design, Design Development/ Preliminary, and Construction/Final Documents stages—vital considerations are maintenance and operational effectiveness, user/occupant needs, energy consumption, cost control, and code/regulatory compliance.

Maintenance and Operational Effectiveness

These characteristics can be designed into a facility by a careful selection of materials for floors, walls, steps, and other interior and exterior surfaces. Materials of known durability, which are easily cleaned or repaired, should be selected. Standardized fixtures, equipment, colors, and types of paint should be carefully chosen. Arrangements of toilet fixtures—such as wall-mounted toilets that leave floors clear for cleaning—should be reviewed. Maintainability of mechanical systems is critical. Sufficient access space must be provided for inspection, cleaning, replacement, and lubrication at scheduled intervals. Maintenance supervisors should review plans and specifications at each stage.

User or Occupant Needs

The reason the facility is being constructed, and the success of the completed project, will depend on how well the occupants' needs have been translated into the completed facility. Authoritative and responsible representatives of the using departments should be invited to be on hand at many stages—selection of the A&E firm, programming, review and approval of schematic and design development plans and specifications, and when construction documents are ready for bidding. The primary representative should sign off at each stage, certifying basic agreement.

Energy Conservation

Conservation of resources is a consideration that must be satisfied in the basic design as well as in the completed facility. Beginning with the institutional standards, which are used as guidelines, the design team should analyze the building envelope, power and lighting schemes, and mechanical equipment and systems to minimize energy consumption. Data should be presented for review and approval by the facilities staff who will monitor the energy-efficient characteristics of the project.

Cost Control

Controlling costs begins with the development of a realistic budget and continues through the various design and construction stages. When there are increases in the scope that increase estimated costs, there should be an increase in the established budget. Firm control of costs in design is one of the professional responsibilities of the design team leader, usually the architect. The facilities staff should review cost estimates at each stage for completeness and validity, comparing data with any comparable recent bid prices whenever possible. The bidding strategy should include identification of alternate bid items to help keep bid prices within the budget.

3.7 CODE AND REGULATORY COMPLIANCE

The consulting architects and engineers must make certain that the construction documents meet the applicable code and regulatory requirements. These may include the local municipality's building code, usually a form of the BOCA Code; handicapped accessibility; fire and life safety; and, in some instances, the requirements of the National Historic Register of Buildings. Some state institutions are exempt from local code requirements, but it is a good practice to follow them unless a significant reason warrants disregarding them.

3.8 INSTITUTIONAL SITE DEVELOPMENT

The A&E team should be aware of special institutional plans and policies regarding design treatment of certain unique types of facilities. In many ways, the institution is like a small city. A design for a new facility must respect the long-range site development plans and policies on a campus in much the same way city zoning and master plan demands are respected.

Pedestrian and Vehicle Access

There may be a plan to have a pedestrian campus with no vehicles on the interior of the campus, and all parking restricted to the perimeter. A new facility's design, in this instance, must give careful consideration to fire lanes and access for supporting services.

Lighting

Security and/or energy conservation may take precedence over aesthetic considerations when planning new exterior lighting. The lighting scheme should complement the facility in a safe, efficient manner.

Graphics

There should be institutional standards for exterior signage and graphics, which all consultants follow.

3.9 VALUE ENGINEERING

Value engineering may be included in design consulting contracts and may be part of a life-cycle cost analysis conducted by the A&E team. Value engineering largely consists of an organized review of the materials and equipment specified and the design details drawn. This review determines where economies may be realized by substituting less costly materials. A life-cycle analysis of costs will provide information on first costs as well as subsequent costs that compose the life-cycle of costs.

Value engineering can also be included in the bidding documents by allowing the contractors to share in any cost savings developed.

3.10 BIDDING STRATEGIES

Lump Sum Fixed Price (LSFP)

There are many bidding strategies used, but the most common is the lump sum fixed price (LSFP) bid made by a general contractor for the entire contract. In this arrangement, the plans and specifications are made available to the general contractors who are bidding on the work. Then bids are submitted with a single sum for all work including site work, structural, mechanical, electrical, plumbing, and perhaps landscaping.

Separate Bids

Separate bids from major subcontractors is a variation of the LSFP method. Separate bids are solicited from the general contractors for excavation, architectural and structural work, and all work that is not specifically mechanical, electrical, plumbing or fire protection. The separate bids obtained from subcontractors for each major section—mechanical, electrical, plumbing, and fire protection—are submitted to the institution for bid opening. Successful bids are assigned to the general contractor for management and coordination of work. The general contractor then includes a management fee in his or her bid. This strategy provides the owner with the savings on subcontract prices that might otherwise be reserved by the general contractors.

The LSFP bidding process allows general contractors the opportunity for bid shopping. They pit one subcontract bid against the other in a secret auction. Having subcontract bids submitted in competition directly to the owner eliminates some undesirable bid shopping. In the process of bid shopping a general contractor, who has submitted a winning low bid, pits one subcontractor against another and successfully reduces their prices in a competitive process. This increases the contractor's profit since the overall bid does not change. The owner gets no price benefit in the process and may, in fact, have one or more unhappy subcontrators on the job.

Guaranteed Maximum Price (GMP)

Competitive bids are solicited from a prequalified list of general contractors before plans and specifications have been completed. The advantages of GMP bidding are—

- The general contractor becomes part of the design team, and his expertise is available to help control costs.
- A bid price is known at an earlier date than with LSFP bidding.

Disadvantages are—

- There will be more change orders.
- Administration is more time-consuming for the owner. After award of a GMP contract to a general contractor, the general takes subcontract bids as plans are completed. The GMP does not increase, however, unless there is an increase in scope during final designs. A contingency fund covers increases in costs.
- The general contractor carefully watches over the plans completed by the A&E team to ensure that the design stays within the original concept.

Cost Plus Fixed Fee (CPFF)

Other bidding strategies such as Cost Plus Fixed Fee (CPFF) are rarely used for institutional work because little or no competition is involved. Using the CPFF method a firm is selected and a contract is signed for the work with the owner compensating the contractor for all costs plus a management fee. It is possible to select a contractor and negotiate a contract price. This could be done if no bids were received or if a particular contractor was wanted for the project.

Construction Manager (CM)

In recent years the popularity of construction management contract arrangements has grown. There are many varieties of the CM contract, but the most common involves negotiation of a CM fee with a selected general contractor. The general contractor manages the contract including all phases of bidding subcontract work. The CM may or may not perform any on-site work. This process has many of the elements of the Guaranteed Maximum Price process, and they may be combined in a GMP/CM contract. The construction manager does most of the contract administration work normally done by the owner and the A&E. There are many variations to CM contracting, and there are times when they may prove advantageous to the institution on large, complex construction projects.

Alternate Bid Items

When planning an LSFP bid, include alternate bid items for use in the event that the low bid exceeds or is less than the estimate. When deductive bid items are used, there is the possibility that the bidder will not deduct profit and overhead costs when showing the amount to be deducted from the base bid. The experience of many owners has shown the additive alternate bid items will be more favorable. This allows the bidder to waive overhead and profit and show only direct costs in order to be more competitive. To show additive bid items, the work would be omitted from the base bid and added by successive alternates.

3.11 BIDDING DOCUMENTS

Bidding documents for on-site construction projects have two basic parts: construction specifications and construction drawings. The construction specifications should follow the format of the Construction Specifications Institute (CSI). The format includes Instructions to Bidders, General Conditions, Supplementary General Conditions, and Technical Specifications. Technical Specifications describe the work in detail, the materials of construction, and the specific technical requirements of the completed work. The construction drawings provide graphic details of the work, the required dimensions of all elements of the facility, as well as graphic representations of the work to be performed.

Simplified Bidding Documents

For smaller, simpler projects that may be started and completed in a relatively short time (one month or less) and have a value of less than an established amount (perhaps $5,000), simplified bidding documents are useful.

Specifications may be printed on the drawings, and the drawings often may only be one or two sheets.

Another means of simplifying bidding documents involves preparation of a form containing three parts: Solicitation of Proposal, Proposal by Contractor, and Acceptance of Proposal. The back of this one-page document contains simplified General Conditions and Supplemental Conditions. Technical Specifications sheets can be added or, again, simply shown on the drawings.

Construction Specifications

Specifications serve as the controlling documents when there is a conflict between the drawings and the specifications.

Legal Requirements

Legal requirements that apply to the construction project are part of the General Conditions and the Supplemental Conditions. These include federal, state, local, and institutional legal requirements such as affirmative action, Davis-Bacon wage rates, public and worker safety, insurance coverage, performance and payment bonds, warranties, and other coverage required of the successful bidder. Publicly supported institutions may have specific legal requirements regarding the length of time the work must be advertised, the publications in which advertisements must be placed, and wording of advertisements. While private institutions may not be required to advertise for bids, it is prudent to seek competitive bids whenever possible.

Alternate Bid Items

As well as a bidding strategy, alternate bid items are sometimes made a part of the bidding documents. When planning a Lump Sum Fixed Price bid, include alternate bid items in case the low bid exceeds or is less than the estimate. Ideally, all alternate bid items should add to the base bid. When alternate items are deducted from the bid, the bidder may not deduct profit and overhead costs when showing the amount to be deducted from the base bid. The experience of many owners has shown that additive bid items will work more favorably. Adding alternate items to the bid allows the bidder to waive overhead and profit and show only direct costs in order to be more competitive. In order to use additive alternate bid items, the work must be omitted from the base bid and added by successive alternates.

3.12 BID CONFERENCES

Pre-bid Conferences

Pre-bid conferences should be planned for any large project and may be beneficial for certain smaller projects. The pre-bid conference is scheduled at the worksite to acquaint bidders with the scope of work and with any unique problems associated with the work. The purpose is to establish direct communications among the architecture and engineering firm, the contractors, and the owner's representatives. Any confusion about the intent of any part of the specifications and drawings can be eliminated at the pre-bid conference. If a bidder guesses about specifications when figuring a bid, the price of unknown work will inflate the bid or lead to claims for extra costs during the contract. The conference contributes to bidding a project successfully.

3.13 RELATIONSHIPS BETWEEN OWNER, CONSULTANTS, AND CONTRACTORS

Careful examination of the contract language in a standard AIA design contract reveals that the architect acts as an intermediary between the owner and contractor. Remember that the architects and engineers have worked with the contractors before the owner's present construction contract, and they will work with the contractors again on later projects. The owner must be in a position to protect the institution's interests without relying solely on the A&E team. Thus the owner, or owner representative, should carefully review plans and specifications prior to bidding and have construction representatives on-site during construction. For example, change order costs should be analyzed to determine responsibility. The owner should approve all shop drawings and change orders. Change orders are discussed in more detail in Chapter 4, "Construction Phase."

Added change order costs may be the result of changes by the owner; errors or omissions by the contractor; unforeseen conditions, errors, or omissions by the consulting team. The owner should be aware that the owner-consultant-contractor arrangement is really three-sided and not owner-consultant on one side and contractor on the other. Keeping a smoothly operating three-member team is important for harmony and can be fostered by an owner with up-to-date information on all details of the design and construction, particularly where cost or quality is involved.

A single representative, however, should be designated at the initiation of the construction contract to speak for the owner and the consultants. This minimizes problems later when many individuals want to give input from all sides. Only the designated representative has the authority to speak to the general contractor on behalf of the owner and the consultants.

3.14 USE OF COMPUTERS IN MANAGING THE DESIGN PROGRAM

Computers can be a useful tool in managing an institution's design program. At the most elemental level, computers can be used to help develop the campus master plan by forecasting long-range space needs. Based on information such as expected enrollment and types of instructional programs, computer programs can project the amount and types of spaces (classrooms, laboratories, offices) required to meet the institution's needs. The institutional planner can create different models based on different assumptions, thus allowing the institution a more flexible master plan. This also enables campus administrators to respond more readily to changing market conditions and student demands.

Space Utilization

A computerized room or facility inventory can also be used as a planning tool in the design program. The first order of business in almost all facility planning sequences is an evaluation of current space allocations. If this information is available on a computer, it can be manipulated in various ways to determine what types of spaces are currently available. Types of space can be combined with scheduling information and personnel data to create a comprehensive evaluation of current space utilization. This management tool can pay significant dividends to the institution. It may be possible to convert underutilized space to other functions at a fraction of the cost of building new space. In addition, if careful records are kept as renovations are performed, utilization data can be combined with facilities condition information to target areas for renovations.

Tracking and Scheduling

Institutional planners may apply computer technology during the design stage to scheduling. Normally, there are several planning projects of various types occurring simultaneously. When this number exceeds five or six, there must be some tool available that will help coordinate these projects and help keep each one in the proper sequence and on schedule. This is especially true when several projects will be undertaken on the same site at the same time. A computer can help managers coordinate and schedule projects over a 3- to 12-month period.

Computers can be used to keep track of consultants available for institutional work, the previous experience and areas of expertise of A&E firms, as well as their track record with the institution. A similar file can be kept on contractors, and both computer files can be used to contract the available work to consultants and contractors who can be depended upon to do a good job.

Finally, computers are obviously useful for the accounting aspects of managing the design program. Keeping close track of A&E project costs manually is a time-consuming task. Payment information and the history of a particular A&E firm or contractor is valuable from a management perspective and is commonly requested by the institution's upper-level managers. Keeping this information in a computer file where it can be rapidly accessed saves limited time.

3.15 CONCLUSION

The Design Phase of a facilities project may represent the culmination of years of effort to obtain funds for a project. In most instances, the completed project will be used for the life of the institution. For these reasons every effort must be made to carefully develop a design program and select a design team likely to succeed. A successful end to the total design and construction effort requires a successful beginning. Attention to detail, diligence in coordination of team members, and avoidance of haste are essential to a successful design.

END NOTES

1. *Compensation Guidelines for Architectural and Engineering Services*, American Institute of Architects, 1735 New York Avenue, N.W., Washington, D.C. 20006.
2. *A Guide to the Procurement of Architectural and Engineering Services*, American Consulting Engineers Council, 1015 Fifteenth Street, N.W., Washington, D.C. 20005.
3. *Uniform Construction Index*, The Construction Specifications Institute, 601 Madison Street, Alexandria, Virginia 22314; or Specification Writers Association of Canada, 1250 Bay Street, Toronto, Canada.

Appendix 3-A

Policies and Procedures for Selecting Architectural and Engineering (A/E) Firms

The following describes the university policies concerning the selection of A/E firms. Such policies include both the Hilltop Campus and the Medical Campus.

1. Policies concerning the selection of A/E firms are adopted by the university's Trustees through the Buildings and Grounds Committee of the Board.
2. It is the policy of the university to encourage consideration of qualified A/E firms and to select, for each project, a firm that is clearly equipped to fulfill the proposed assignment in the best interest of the university. Such selections are to be made objectively. In order to fulfill this policy, the following procedures have been instituted:
    (a) The Hilltop Campus Administrator of Physical Facilities and Vice Chancellor for Medical Affairs or their designee shall maintain a file of descriptions of firms who wish to be considered for assignments.

    (b) The Hilltop Campus Administrator of Physical Facilities and Vice Chancellor for Medical Affairs or their designee will prepare, once a year, a list of all the A/E firms used in the preceding year for review by the Buildings and Grounds Committee.

    (c) Except for major projects, the administration of each campus shall adopt procedures appropriate for each assignment that shall assure opportunities for a number of qualified firms.

    (d) A/E firms to be selected for projects of any size that involve significant architectural or engineering questions—redesign of the exterior of the building, major engineering and site planning, or change in interior spaces of significant architectural or engineering importance as determined by the administration of the respective campuses—shall be reviewed with the Chairman of the Buildings and Grounds Committee or his/her designee before an assignment is made.

(e) A/E selection for major projects such as new buildings, or any remodeling with a cost in excess of $500,000, shall be done under a system of review described in the following section entitled Procedure for Selecting Architectural/Engineering (A/E) Firms for Major Projects.

Procedure for Selecting Architectural and Engineering (A/E) Firms for Major Projects

1. The Administrator of Physical Facilities for Hilltop Campus projects and Vice Chancellor for Medical Affairs' office for Medical Campus projects will compile and maintain a file of A/E firms that are potential candidates for doing work for the university. (The two campuses will work jointly in the development of approved lists.)
2. When a construction project is proposed, the Administrator of Physical Facilities or the Vice Chancellor for Medical Affairs or their designee will prepare a description of the project, including the scope of work, the identification of applicable campus standards, relationship of campus development plans, a timetable, and a budget.
3. At the same time, the Administrator of Physical Facilities or the Vice Chancellor for Medical Affairs or their designee will select a list of firms from the file. Selection of firms will be based upon preliminary review comparing the nature of the job with the experience of the firm and other significant factors.
4. The firms selected will be sent a description of the project and a questionnaire designed to obtain more detailed information related to the specific project. Those firms that respond will be interviewed by a selection committee. The selection committee will be composed of the Chairman or designated member of the Buildings and Grounds Committee, the Chairman of the Campus Physical Planning Committee (for Hilltop projects), a representative of the administration, the Administrator of Physical Facilities or the Vice Chancellor for Medical Affairs or their designee, and a representative of the functional area in which the project is located. This committee will review the information at hand and the scope of the work prior to conducting interviews with the principals of the firms. The selection committee will select up to three firms from the original group as the finalists, and these firms will be ranked.

5. The firm ranked first will be asked to make a comprehensive written and oral presentation demonstrating its methods and experience related to the project, which principals would be assigned to the job, the consultants to be used, a schedule of document preparation, estimating procedures, services during construction, and any other information helpful in determining how well the particular firm is qualified to do the job.
6. The committee should then reach a decision as to whether or not to proceed with fee negotiations with the selected firm. If the parties reach an agreement, a contract will be signed and the other firms will be promptly advised.
7. If the first-ranking firm's proposal is not satisfactory, negotiations will be initiated with the second-ranking firm. Again, if the negotiations are unsatisfactory, the committee will negotiate with the third-ranking firm.

   If these negotiations prove unsatisfactory, the project will be restudied and the university's expectations will be reexamined before beginning the process again.
8. All proceedings of the selection committee shall be held in strict confidence.

Appendix 3-B

Architecture/Engineering and Related Services Questionnaire

PURPOSE:

Our purpose in requesting the completion of this questionnaire is to assemble a file of qualified architects and engineers who are interested in doing work for XYZ University. While we do not have a specific job in mind at this moment, your answers will help us identify firms with interest, capacity, and experience that correlate well with projects as they arise in the future.

INSTRUCTIONS FOR FILING (numbers below correspond to numbers contained in form):

1. Type accurate and complete name of submitting firm, its address, and zip code.
   1a. Indicate whether form is being submitted on behalf of a parent firm or a branch office. (Branch office submission should list only personnel in, and experience of, that office.)
2. Provide date the firm was established under the name shown in question 1.
3. Show date upon which all submitted information is current and accurate.
4. Enter type of ownership, or legal structure of firm (sole proprietor, partnership, corporation, joint venture, etc.)
   4a. Check appropriate box indicating if firm is minority owned.
5. Branches or subsidiaries of larger or parent companies, or conglomerates, should insert name and address of highest-tier owner.
   5a. If present firm is the successor to, or outgrowth of, one or more predecessor firms, show name(s) of former entity(ies) and the year(s) of their original establishment.
6. List not more than two principals from submitting firm who may be contacted. Listed principals must be empowered to speak for the firm on policy and contractual matters.

7. Beginning with the submitting office, list name, location, telephone numbers, and number of personnel for all associated or branch offices (including any headquarters or foreign offices) that provide A/E and related services.

   7a. Show total personnel in all offices. (Should be sum of all personnel, all branches.)

8. Show total number of employees, by discipline, in submitting office. (If form is being submitted by main or headquarters office, firm should list total employees by discipline in all offices.) While some personnel may be qualified in several disciplines, each person should be counted only once in accord with his or her primary function. Include clerical personnel as administrative. Write in any additional disciplines—sociologists, biologists, etc.—and number of people in each, in blank spaces.

9. Using chart (below) insert appropriate index number to indicate range of professional services fees received by submitting firm each calendar year for last five years, most recent year first. Fee summaries should be broken down to reflect the fees received each year.

   Ranges of Professional Services Fees

   Index:

   1. Less than $100,000
   2. $100,000 to $250,000
   3. $250,000 to $500,000
   4. $500,000 to $1 million
   5. $1 million to $2 million
   6. $2 million to $5 million
   7. $5 million to $10 million
   8. $10 million or greater

10. Select and enter, in numerical sequence, *not more than twenty* (20) Experience Profile Code numbers from the listing below that most accurately reflect submitting firm's demonstrated technical capabilities and project experience. *Carefully review list.* (We recognize that some profile codes may be part of other services or projects contained on the list. Select profile codes that best indicate type and scope of services provided on past projects.) For each code number

show total number of projects and gross fees (in thousands) received for profile projects performed by firm for past five years. If firm has one or more capabilities not included on list, insert same in blank spaces at end of list and show numbers in question 10 on the form.

11. Using the Experience Profile Code numbers in the same sequence as entered in item 10, give details of at least one recent (within last five years) representative project for each code number, up to a *maximum of twenty* (20) separate projects, or portions of projects, for which firm was responsible. (Project examples may be used more than once to illustrate different services rendered on the same job. Example: a dining hall may be part of an auditorium or education facility.) Firms that select fewer than 20 profile codes may list two or more project examples (to illustrate specialization) for each code number as long as total of all project examples does not exceed 20.

    After each code number in question 11—

    - Show whether firm was P, the prime professional; C, a consultant; or JV, part of a joint venture on that particular project. (Firms less than five (5) years old may use the symbol IE to indicate individual experience as opposed to firm experience).
    - Provide name and location of the specific project that typifies firm's (or individual's) performance under that code category.
    - Give name and address of the owner of that project.
    - Show the estimated construction cost (or other applicable cost) for that portion of the project for which the firm was primarily responsible. (Where no construction was involved, show approximate cost of firm's work).
    - State year work on that project was, or will be, completed.

12. The completed form should be signed by a principal of the firm, preferably the chief executive officer.

13. Additional data, brochures, photos, etc. may accompany this form.

Experience Profile Code Numbers
(For Use With Questions 10 & 11)

001 Acoustics, Noise Abatement
003 Agricultural Development, Grain Storage, Farm Mechanization

004 Air Pollution Control
005 Airport, Navaids, Airport Lighting, Aircraft Fueling
006 Airports, Terminals & Hangars, Freight Handling
007 Arctic Facilities
008 Auditoriums and Theatres
009 Automation, Controls, Instrumentation
010 Barracks, Dormitories
011 Bridges
013 Chemical Processing and Storage
014 Churches, Chapels
015 Codes, Standards, Ordinances
016 Cold Storage, Refrigeration, Fast Freeze
017 Commercial Buildings (low rise), Shopping Centers
018 Communications Systems, TV, Microwave
019 Computer Facilities, Computer Service
020 Conservation and Resource Management
021 Construction Management
022 Corrosion Control, Cathodic Protection, Electrolysis
023 Cost Estimating
024 Dams (Concrete, Arch)
025 Dams (Earth, Rock), Dikes, Levees
027 Dining Halls, Clubs, Restaurants
028 Ecological and Archeological Investigations
029 Educational Facilities, Classrooms
030 Electronics
031 Elevators, Escalators, People-movers
032 Energy Conservation, New Energy Sources
033 Enviromental Impact Studies, Assessments or Statements
034 Fallout Shelters, Blast-Resistant Design
035 Field Houses, Gyms, Stadiums
036 Fire Protection
039 Garages, Vehicle Maintenance Facilities, Parking Decks
040 Gas Systems (Propane, Natural, etc.)
041 Graphic Design
042 Harbors, Jetties, Piers, Ship Terminal Facilities
043 Heating, Ventilating, Air Conditioning
044 Health Systems Planning
045 Highrise, Air-Rights-Type Buildings
046 Highways, Streets, Airfield Paving, Parking Lots
047 Historical Preservation
048 Hospitals and Medical Facilities
049 Hotels, Motels
050 Housing (Residential, Multifamily, Apartments, Condominiums)

051 Hydraulics and Pneumatics
052 Industrial Buildings, Manufacturing Plants
053 Industrial Processes, Quality Control
054 Industrial Waste Treatment
055 Interior Design, Space Planning
056 Irrigation, Drainage
057 Judicial and Courtroom Facilities
058 Laboratories, Medical Research Facilities
059 Landscape Architecture
060 Libraries, Museums, Galleries
061 Lighting (Interior Display)
062 Lighting (Exterior, Streets, Memorials, Athletic Fields, etc.)
063 Materials Handling Systems (Conveyors, Sorters)
066 Military Design Standards
067 Mining and Mineralogy
069 Modular Systems Design, Pre-fabricated Structures or Components
071 Nuclear Facilities, Nuclear Shielding
072 Office Buildings, Industrial Parks
075 Petroleum Exploration, Refining
076 Petroleum and Fuel (Storage and Distribution)
077 Pipelines (Cross-country—Liquid and Gas)
078 Planning (Community, Regional, Areawide, and State)
079 Planning (Site, Installation, and Project)
080 Plumbing and Piping Design
081 Pneumatic Structures, Air Support Buildings
082 Postal Facilities
083 Power Generation, Transmission, Distribution
084 Prisons and Correctional Facilities
088 Recreational Facilities (Parks, Marinas, etc.)
089 Rehabilitation (Buildings, Structures, Facilities)
090 Resource Recovery, Recycling
092 Rivers, Canals, Waterways, Flood Control
093 Safety Engineering, Accident Studies, OSHA Studies
094 Security Systems, Intruder and Smoke Detection
095 Seismic Designs and Studies
096 Sewage Collection, Treatment and Disposal
097 Soils and Geologic Studies, Foundations
098 Solar Energy Utilization
099 Solid Wastes, Incineration, Landfill
100 Special Environments, Clean Rooms, etc.
101 Structural Design, Special Structures
102 Surveying, Platting, Mapping, Flood Plain Studies

103 Swimming Pools
104 Storm Water Handling and Facilities
105 Telephone Systems (Rural, Mobile, Intercom, etc.)
106 Testing and Inspection Services
107 Traffic and Transportation Engineering
108 Towers (Self-Supporting and Guyed Systems)
109 Tunnels and Subways
110 Urban Renewal, Community Development
111 Utilities (Gas and Steam)
112 Value Analysis, Life-Cycle Costing
113 Warehouses and Depots
114 Water Resources, Hydrology, Ground Water
115 Water Supply, Treatment, and Distribution
117 Zoning, Land Use Studies

201 ______________________________

202 ______________________________

203 ______________________________

204 ______________________________

205 ______________________________

CHAPTER 4

Construction Phase

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4.1 INTRODUCTION

The construction phase starts after the selection of a project contractor, through a competitive bid or a negotiated procedure. This phase begins with the issuance of the contract to the successful contractor.

4.2 CONTRACT DOCUMENTS

There are two major contractor documents: the Project Manual and the Project Plans. The Project Manual consists of the contract, bonds, general conditions, and technical specifications. The Project Plans are the graphic presentation of the project. Normally the Instructions to Bidders, Project Advertisement, and Bid Bond are not considered contract documents although they were a part of the bidding documents.

Contract

Once a decision has been reached on the firm to undertake the construction, a formal agreement must be signed that identifies the rights and responsibilities of each party. This agreement must contain all of the following elements:

- Identification of parties. The two parties to the construction contract, contractor and owner, must be listed by the names by which they are legally organized.
- Statement of work to be performed. This statement should include the name of the project and specifically enumerate the various documents that define the project—General Conditions, Supplementary Conditions, Drawings, Specifications, and Addenda. (See Chapter 3, "Design Phase," 3.10 Bidding Documents.)

- Statement of the consideration. This may be a simple statement of the contract amount in a stipulated sum form of contract. Or it may be rather complex, where the total contract amount is based on unit prices or on cost plus some form of profit identifier.
- Insurance and bonding. The contractor must show proof of adequate and appropriate insurance coverage for the project. In some instances there may also be special insurance obtained by the institution for the project.

  The contractor must also acquire the bonds required by the project General Conditions. The bonds must be obtained and delivered to the appropriate campus administrator prior to any payments being made on the project.
- Time of performance. Every contract must include a time duration. This may be in the form of a fixed date or a statement of allowed time identified in either work days or calendar days.
- Signatures. The contract, to be valid, must be signed by the duly authorized agent of each party to the contract. The owner's contracting officer should require the contractor's agent to provide proof of his signatory authorization unless such proof is on file from previous contracts.

Several professional organizations, many trade organizations, all levels of government, and many owners have drafted forms of contract agreements that are useful. Two professional organizations have established prominence in contract forms and produce the most commonly used ones. For architectural projects, contract forms may be obtained from the American Institute of Architects (AIA), 1735 New York Avenue, N.W., Washington, D.C. 20006; and for engineering projects, contract forms developed by the Engineering Joint Contract Documents Committee (EJCDC) may be obtained from The Construction Specifications Institute, 601 Madison Street, Alexandria, Virginia 22314, or the National Society of Professional Engineers, 2029 K Street, N.W., Washington, D.C. 20006.

4.3 NOTICE TO PROCEED AND PRE-CONSTRUCTION CONFERENCE

Notice to Proceed

As soon as the contract has been signed, all insurance certificates obtained, and all bonding requirements met, the owner's contracting officer can issue a Notice to Proceed to the contractor. In many instances an alternative procedure is used, permitting some time savings. This procedure involves issuance of a letter of intent. This letter, when signed by the contracting officer for the college or university, serves as an interim contract. The letter of intent authorizes the contractor to proceed with the project as soon as all necessary insurance requirements are met. This interim contract terminates once the formal contract is signed. This will allow the contractor to order material and begin preliminary work on the project.

Pre-construction Conference

The pre-construction conference is a coordination meeting attended by representatives of the contractor, the major subcontractors, the design firm, the institution, and the state (if appropriate). Depending upon the requirements of the Project Manual, this meeting may be called by the designer, the contractor, or the campus representative.

No matter who calls or chairs the conference, the topics of discussion are the same: use of power and water, parking, emergency procedures, access to construction site, site security, location of temporary facilities, storage areas, and location of contractor's project office. The pre-construction conference provides an ideal opportunity to discuss procedures for submitting shop drawings, processing payment requests, change order procedures, and establishing lines of communication and authority. The conference also visibly fixes decision making responsibility with the single designated representative from the institution, state, designer, and contractor.

4.4 CONTRACT ADMINISTRATION

Contract administration includes a wide range of activities, all of which are vital to the successful completion of the project. The following subsections will describe several of the major aspects of contract administration as they relate to a campus project.

Project Inspection

It is vitally important that the project be inspected during the construction process to insure compliance with the plans and technical specifications. Inspections will also facilitate the resolution of questions that arise during construction.

One alternative is to require that the project designer provide a full-time or part-time inspector in addition to the inspection services required under the design agreement. This alternative reinforces the designer's responsibility for assuring conformance with the contract documents.

A second alternative is for the inspection to be provided by a person employed by the campus. Although there are some advantages to this alternative, it does remove the independent judgment and the unbiased position of the design firm from the inspection process.

In addition to the regular project inspection, the campus should provide periodic inspection by experienced staff members. The intent of this inspection should be to identify deviation from the contract documents as well as errors or omissions in the design and specifications. Staff inspection will also aid evaluation of requests for changes from the approved construction documents. The campus inspector should also watch for and identify possible future maintenance and operations problems.

Change Orders

Change orders amend the original project contract. The change order should be reviewed by the project designer and signed by the same people who signed the original contract, or others properly authorized to sign these documents.

Because the change order is an amendment to the original contract, it requires all the elements of the original contract agreement: identification of parties, statement of work, statement of consideration, time of performance (effect on original contract completion date), and signatures. Any change order should also be supported with complete details of the change.

In addition to being a formal order for change in the contract, a change order helps provide a record of actual construction. To maintain an accurate record, all changes in the project should be made with formal change orders, rather than informal verbal authorizations.

Change orders occur for two basic reasons: errors or omissions in the design, and changes in methods or materials desired by the owner. In a conventional competitive bid, stipulated sum contract, the former reason is most prevalent.

The institution can reduce the possibility of change orders resulting from errors or omissions by insisting upon a detailed review of the plans and Project Manual by the staff of the plant department. The plan review team should include staff engineers as well as foremen of various trades. The investment of time and energy in a detailed plan review will pay off many times over in reduced change orders.

An extensive review by the plant staff and shop foremen will also reduce the number of the change orders or subsequent project modifications required. The staff can note technical specifications permitted, brand names, or materials not otherwise used on the campus.

It will be helpful in controlling change order costs if the project's general or supplemental conditions include limits on the extent of markup permitted on change orders. A further control on change order costs is the inclusion of selected unit price quotations in the contractor's original bid. Unit prices are commonly a part of the stipulated sum proposal in concrete and excavation work as a way of adjusting the contract amount when subsurface conditions are unclear.

Allowance

An allowance is a predetermined dollar amount established in the contract to cover the cost of either material or work, because the exact details are unknown when the contract is awarded. An allowance permits the owner to maintain closer control of the exact nature of the item than might be possible if the item is described in the bidding documents. Allowances are also used if the designer wants close control of the aesthetics of an item or if the item is an artistic creation such as a painted mural.

Shop Drawings

Shop drawings are construction details or detailed product explanations submitted by the contractor for review by the designer. Normally the project specifications will identify all items requiring a submission by the contractor.

Shop drawings should be fully reviewed and approved by the designer and owner. Care must be taken to assure that approval of shop drawings means the drawings conform to design concepts. If the shop drawings require other changes in the project creating additional costs, the project general conditions normally make the contractor responsible for the increased cost. Any question of additional compensation should be settled in the process of the shop drawing approval. This helps avoid claims later on in the project when they may be more difficult to resolve equitably. Any approved change in the contract amount must be documented through issuance of a change order.

The institution should obtain a copy of all shop drawings at the end of the construction project. These documents provide invaluable information to the maintenance and operations crews. And they provide a historical record of the facility.

Payments

Progress payments for completed work are usually made to the contractor on a monthly basis. For small projects or under some special conditions it may be desirable to permit on-demand payment requests from the contractor. The frequency of payments, as well as the process for submission of payment applications, must be detailed in the project General Conditions.

Punch Lists

Punch lists tabulate deficiencies or incomplete items. The designer and owner prepare a punch list by conducting a final inspection after the contractor says the project is complete. The institution's representative should coordinate participation in this final inspection with the designer.

Not all problems identified in this inspection process will result in an item on the punch list. All identified problems must be checked against the project plans and specifications to determine if the work was performed in accordance with the project contract. Where problems remain, but are outside the original project requirements, the necessary corrections might be made through a change order or corrected after acceptance of the project.

Once the punch list is developed by the design firm, copies are sent to the contractor and owner. This distribution of the punch list is formal notification to the contractor of the items that must be completed or corrected before the total contract can be considered complete and final payment made. Final payment should be held until the punch list items are completed.

Owner/Operator Training

Each new facility brings with it a new set of operating problems. For this reason the contract documents should require a period of owner/operator training immediately prior to the time the facility is turned over to the owner. This includes demonstration of all systems through their entire range of operation.

Owner/operator training should include a brief explanation of each operating system, of start-up and shut-down procedures, and of necessary equipment maintenance. Each building system should be operated at full load, tested, and cleaned by the contractor prior to acceptance by the owner, with the owner's representative present.

For owner/operator training to be successful, the plant department must schedule appropriate maintenance and operating personnel to participate in the training. Even though this may appear to be a substantial investment in time, the benefits in future reduced maintenance problems will show the investment was well worth it.

Maintenance and Operation Manuals

The best owner/operator training cannot eliminate the need for maintenance and operation manuals. In fact, these manuals should be textbooks for the owner/operator training program.

The plant administrator should develop the overall requirements for the equipment maintenance and operating manuals. And the operating manuals should be arranged in the same sequence as the Project Manual. They should include manufacturer's literature, suggested maintenance schedules, parts lists, and names of local service or manufacturer's representatives.

The maintenance and operation manuals should also include engineering design criteria. Inclusion of design loads and similar information will facilitate future adjustments caused by changes in building requirements.

Record Drawings

The contract agreement should require the contractor and all subcontractors to maintain, at the job site, a set of project drawings on which all changes are noted. At the completion of the project, these marked-up drawings should be returned to the project designer so the original design drawings can be corrected. Once the original drawings have been corrected, the institution's physical plant department should obtain a copy of the drawings on a reproducible medium.

These record drawings (formerly called as-built drawings) will prove their worth during the normal maintenance process. The value of record drawings will be greatly magnified when alterations or major renovations are undertaken.

Warranties and Guarantees

Normally the construction contract documents will provide for a one-year guarantee on the entire construction project. Designating when the warranty period begins is critical because of possible supplier and contractor obligations to the warranties. For example, the contractor could install and use an elevator during construction. That time may run against the supplier's warranty to the detriment of the owner.

As a part of the owner/operator training program, the designer should explain the requirements of the individual warranties and guarantees. This explanation should include maintenance requirements or other actions required to keep the warranties and guarantees in force. The designer should also explain the process to follow in case it is necessary to file a claim under any of the warranties or guarantees.

Spare Parts

The contract should provide for spare parts to be turned over to the physical plant department at the completion of the project. This provision is especially important for items that may be difficult, if not impossible, to match in color or texture after a few years, such as ceiling tile, floor tile, or carpet. It may also be valuable to obtain spare parts that are critical to a system operation and have long lead times when ordered. Any requirements for the spare parts must be clearly identified in the Project Manual.

Test Reports

The plant department may require copies of testing and/or balancing reports on the various mechanical systems. For example, a copy of the balancing report on an air distribution system may be invaluable if adjustments are required because of alterations or changes in function.

4.5 PROJECT ACCEPTANCE AND OCCUPANCY

Under ideal conditions, the contractor completes the project, including all items on the punch list. Then the owner/institution formally accepts the project, and occupancy follows. This ideal condition seldom, if ever, occurs. Delays in the delivery of critical material, weather, or approved changes frequently contribute to delays in actual project completion.

The final acceptance normally occurs when the designer certifies that the contractor has completed all work according to project plans and specifications. If the contractor has complied with all contract requirements, he is eligible to request final payment following acceptance of the building by the owner.

Because the institution may need to occupy the building, it may be necessary to accept the building for beneficial occupancy or substantial completion. Under this form of acceptance, both parties acknowledge that the project is not complete. The facility, however, can be used by the owner. Occupying the building under these circumstances requires the cooperation of both parties since work continues after the building is occupied. This arrangement presents additional safety, operational, and cost concerns. Occupancy prior to final completion should be avoided, unless there are compelling reasons that justify the additional risks.

There are two special concerns to consider if early occupancy is required. First, the project insurance must be reviewed and any necessary endorsements added to permit building occupancy prior to completion. Second, careful records must be maintained to document responsibility for any problems encountered during completion of the project.

The date of acceptance, beneficial occupancy, or substantial completion must be documented. This date should establish the beginning of the warranty/guarantee period unless other procedures are established in the contract documents.

Although it may appear to be a simple process, the acceptance and occupancy of a project present many legal and operational issues that must be considered. Good documentation will help to resolve and eliminate many potential problems. Some of these issues are identified below.

Mechanic's Liens

Although the law may vary from state to state, all states have legal provisions to assure contractors and material suppliers of payment for materials incorporated into a construction project. If the prime contractor fails to pay the subcontractors or material suppliers, the unpaid party may file with the court a legal claim for payment. This claim, a Mechanic's Lien, requires the project owner to satisfy the unpaid bills or the court may sell the property to pay the claim.

To protect against the possibility of a Mechanic's Lien, the contractor, subcontractors, and material suppliers should provide Lien Waivers (or Lien Releases) before approval of the final payment on the project contract. This Lien Waiver is an agreement that the party will not file a Mechanic's Lien against the project.

Insurance

The appropriate transfer of insurance coverage must be considered as a part of any plan of occupancy. Many forms of builder's risk insurance include either an automatic termination clause or a requirement for formal approval by the insurance carrier if the building is to be partially occupied prior to formal acceptance.

Utilities

Normally the construction contractor is responsible for all utility costs during the construction period. Appropriate arrangements must be made for the distribution of utility costs at the time of acceptance or partial occupancy.

Building Security

During the construction phase, the contractor will normally have full responsibility for site and project security. Once the institution occupies any part of the facility, different arrangements must be made to assure appropriate security for occupants and building materials.

4.6 ALTERNATE CONSTRUCTION PROCESSES

The most common method for major campus construction is the conventional construction process. The design work is completed, then the bidding process leads to selection of one or more contractors to complete the construction. There are many alternatives to this process that may be useful under certain circumstances. Before embarking on any deviation from the normal process, check for existing legal requirements or institutional policy. For many public institutions, state law requires construction projects to be awarded by competitive bid.

Following are explanations and definitions of some alternatives to the competitive bid process based on a completed design. These alternatives are intended to save time and money in the construction process. Each alternative will vary and usually increase the involvement of the owner in the project. The success of the alternative will depend on the owner's knowledge, ability and expertise in construction management.

Design-Build

Under this form of project development, one firm usually has responsibility for both the design and the construction of the facility. It is possible to use the design-build format in a competitive bid process. To do so requires extensive program planning and a method of analyzing the proposals submitted by design-build firms. This construction process gets the project under construction as the plans for each segment are completed, rather than waiting for the total project design. It saves time, and therefore money.

The use of the design-build concept for campus buildings is limited because of the need to develop extensive program material. Use may also be limited by the strong desire for design compatibility of the various campus buildings. There are some types of campus facilities that might be considered for design-build. These are parking garages, warehouse buildings, dormitories, or other structures the institution wants to duplicate. The institution would work with the design-build firm that built the original facility(ies).

This format saves some time because the design and construction phases overlap. It controls cost because a price for the project is established early in the design process.

Fast Track

This process compresses the time between start of design and completion of construction. The fast track works well on relatively large projects and can be adapted to either competitive bid or negotiated contracts.

Time is saved by starting construction on selected parts of the project prior to the completion of designs. For this to occur, the designer must complete segments of the construction documents in a sequence that generally follows the proposed sequence of construction. A separate contract is then awarded for site excavation as soon as the size, shape, and depth of foundation is determined. Excavation can begin before detailed design of the foundation is complete. Once the foundation design is finished, work is contracted. Then other portions of the design are completed later.

The fast track process requires careful cost-estimating allocation to assure funds are sufficient for the entire project. This time-saving process also restricts the designer's ability to incorporate desired changes into the project after the initial construction contracts are awarded.

Construction Management

This procedure is intended to add some professionalism to the project development process. Where permitted by state law or campus policy, hiring a construction manager may reduce the total project cost or the time to design and construct the project. If the institution has competent people on its own staff, it may provide the construction management function without hiring additional people.

Although the term construction management (CM) has been used for several years, the definition has not been standardized. There are three generally accepted CM practices, with the difference primarily related to when the construction manager is hired.

In one form of construction management, the construction manager is retained by the building owner at the earliest stages of the design. The construction manager then becomes a full partner in the design process, offering his or her special expertise to assure the use of economical design and construction methods.

In a second form of construction management, the construction manager is retained following the completion of the design and is responsible for the construction process. The construction manager is responsible for helping the owner obtain contractors for the various segments of the project, providing project coordination, and expediting the work.

In a third CM model, the construction managers may actually perform portions of the work with their own crews or contract for the work with other firms if it is less expensive.

Turn Key

A turn key project differs from other construction methods in financing. In a turn key project, the contractor or developer arranges for and obtains all necessary construction financing. Once the project is complete, the contractor exchanges the title of the building for either full payment or an agreement for future payments.

This method of construction may have application if the institution does not have access to interim financing or if interest rates make it advantageous to keep institutional funds invested as long as possible. This approach may also have some application if the project will generate income, such as a residence hall. Using the turn key approach and having the contractor/developer hold a mortgage on the property will permit paying for the project's construction with income generated by the project.

4.7 ALTERNATIVE FORMS OF CONSTRUCTION CONTRACTS

For most colleges and universities, the usual construction contract is the stipulated sum form. The contract is awarded based on a fixed price. This fixed price may be reached through competitive bidding or through negotiation.

In recent years, high interest rates and inflation have suggested other possible forms of contract. The advent of construction management with fast track and design-build alternatives may help institutions gain some of the benefits of innovative construction contracts. The following briefly explains some of the common contract alternatives.

Guaranteed Maximum Price

Guaranteed maximum price (G-Max) establishes a maximum project cost and then provides incentives to the contractor to reduce this cost. A maximum cost of the project is obtained through competitive bid or negotiation. The contract documents go on to provide a formula or method of apportioning the financial savings. These savings result from cost reductions implemented during the construction process that are agreed upon by the contractor and owner.

This process shifts a considerable amount of design responsibility to the contractor. The designer and owner must review all the cost-saving measures proposed by the contractor to determine their acceptability.

The major difference between design-build and G-Max is that in the latter the owner has control of the detail design and must review proposed deviations from the design. In design-build the contractor has overall responsibility for the detail design with owner review and approval.

The G-Max form shifts most of the responsibility for design omissions to the contractor. This shift of responsibility may have an influence on the guaranteed maximum price contained in the contract if the plans and/or specifications are not complete.

Cost Plus a Percentage

Using this method, the owner pays the actual cost of the project plus a fixed percentage, which is intended to cover the contractor's overhead and profit. The major shortcoming to this form is that it provides no incentive to control costs.

Cost Plus a Fixed Fee

Cost plus a fixed fee tries to solve some of the problems associated with cost plus a percentage. Although it contains no incentive for reducing costs, it does eliminate any incentive to drive the cost upwards.

Cost Plus a Fixed Fee With Upset Figure

This form of contract is an attempt to combine the positive factors from several forms of negotiated contract. It establishes a fixed cost ceiling for the completed project for the owner. It also assures the contractor a profit as long as the cost remains below the fixed cost ceiling.

Multiple Prime Contracts

Most college and university facilities are constructed with a single prime contract that covers the entire project. An alternative to this process is to award multiple prime contracts. Each of the prime contractors has a direct contractual relationship with the owner. In this process the institution must hire a construction manager, require one of the multiple prime contractors to provide project coordination, or the owner must serve as construction manager.

4.8 USE OF COMPUTERS IN CONSTRUCTION PROGRAM MANAGEMENT

Computers can be especially useful in three areas of the construction program: payments, schedules, and change orders.

Payments

Computer management of payments to both the architecture and engineering firms and contractors is virtually required to administer construction contracts. This is especially true when using construction management techniques or multiple prime contractors instead of a single prime contractor. In these situations, one could have as many as 20 or 30 contracts for a single project. Obviously, some mechanization of function is necessary in such situations.

Scheduling

Closely related to payments is the use of the computer to keep track of construction schedules. Most construction firms prepare detailed schedules of events on a construction project in order to schedule the work of subcontractors and the delivery of material. Construction management firms universally require such documents and use them extensively during the project. By comparing such schedules to actual completion time, bottlenecks in the construction process are identified quickly and remedied before throwing the entire project behind schedule. Such schedules can also serve as the basis for contractor billings and possible liquidated damages, if the project is not completed in a timely manner.

Change Orders

Change orders on a project can be divided into two types. Pending change orders are those suggested changes not yet approved by all parties. Approved change orders are those changes to the contract that have been approved. There are normally more pending change orders than approved change orders during the course of a construction project. It is important that all parties to the contract be kept informed of the change orders actually approved, those still pending, and the affect of both upon project contingency funds. Without current and complete information of this kind, it is difficult to properly manage a large construction project. The best way to make sure that everyone has timely and accurate information is to keep this record in a central computer file. Complete reports can then be printed on a regular basis. This procedure helps assure that all contingency funds are used economically and that only justified contract changes are approved.

4.9 CONCLUSION

To assure that a successful design is translated into a successful building, the campus project managers must fully understand the legal requirements of the contract, as well as the responsibility for contract administration. Project managers must assure that the project is on time and on budget. Managers must be knowledgable of both alternative contruction methods and alternative contract forms. In general, project managers must be a storehouse of information about the total project.

The Construction Phase can make or break a good design. Lack of attention to the actual construction can result in a less than desirable finished product. The lack of attention can also lead to higher than normal operating and maintenance costs for the facility.

For many people on campus, the Construction Phase is the first opportunity to see the fruits of months of planning. And the first signs of construction will bring out many sidewalk superintendents. Campus project administrators must be sure, once the contract is awarded, that the project moves smoothly and in a timely manner to a successful completion. Otherwise they will have to defend their actions to immediate supervisors, as well as actual and potential occupants. It may be possible to explain the delays or problems to a supervisor, but our customers/clients never fully understand why there were delays and disputes, or why they must occupy a less-than-perfect building.

PART VI

CONCLUSION:
Evaluating Plant Management

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CONCLUSION: Evaluating Plant Management

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CONCLUSION

Evaluating Plant Management

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The credibility of the plant department's management is frequently questioned by faculty, other administrators, staff, and students. We should remember that we are as others perceive us to be.

Occasionally it is necessary to examine and evaluate the department's activity and its net results as perceived by the faculty, administration, staff, and students. Periodically we need to reshape our operations to achieve the most cost-effective operations possible while meeting—to the greatest extent possible—the needs of those we serve.

Several reasons, some more realistic than others, may prompt an evaluation of the management of a department. These include—

- Budget constraints and adjustments (layoffs, belt tightening, less money).
- Complaints about plant services from academic departments, campus organizations.
- Complaints/grievances from employees (unions, layoff restrictions).
- Complaints from outside the campus community (contractors, suppliers).
- Pressures from the governing board (contracting outside services).
- Internal campus political forces.
- The president or business officer may perceive the plant operation to be ineffective, too expensive, and inefficient.
- Organizations need to undergo critical self-examination from time to time to maintain the organization's health.

A management audit helps managers by evaluating (1) the internal controls of the organization and (2) the extent of compliance with the institution's policies, procedures, and external regulations.

THE AUDIT FOUNDATION

A consultant may evaluate the management of a plant department, or institutional managers may conduct an internal self-study. The consultant should have experience in broad management studies rather than only financial accounting and fiscal management. Internal self-evaluations should be conducted periodically if only to confirm the organization's efficient operation, and to avoid slipping into a rut organizationally.

External or internal studies follow a basic process that focuses on five basic questions:

- What do you do?
- Why do you do it?
- How well do you do it?
- How well does what you do relate to why you do it?
- What difference does it make whether you do it or not?

The answer to the first question requires listing the activities or functions associated with the plant. Analysis of the department's basic mission or purpose is needed to answer the second question. A detailed statement of the quality and effective management of the department's operation answers the third question. The fourth question requires analysis of the relation of the physical plant's functions to the institution's stated goals and objectives. An assessment of the value or worth of the functions performed answers the fifth question.

Searching for and finding answers to these questions lays the foundation for total plant management improvement—the aim of any evaluation. How does the plant administrator know, how does the boss, or president, or trustees know if you are doing a good job (or not doing the best job) managing the physical plant organization?

THE PHYSICAL PLANT DEPARTMENT

How does one know if the plant department is managed efficiently and effectively? How does the director of the plant department know if he or she is managing well? How can he or she prove it? How can the chief business officer disprove it? There are a number of subjects that have a bearing on a good plant management profile.

The Mission: Why Do We Do It?

A department as large as the physical plant must have a purpose and a place in the institution's organization. The plant director should be able to identify that place. Is it a formal statement and published, possibly in the faculty handbook? Or is the mission based on tradition and understood by certain key people?

Documentation of the mission of the plant department and appropriate publication must be the responsibility of the chief business officer, certainly not that of the plant director. The plant department, in order to function as an asset to the educational environment, must meet the stated objectives and purposes of the institution.

An example of a plant department mission statement follows.

Purpose The basic purpose of the plant department is to aid in the creation of a physical environment for education and research, to operate and maintain the physical plant portion of this environment, and to provide services that enhance the use of facilities. This is done in a manner consistent with the goals, objectives, and criteria established by university administration and the state.

Major Objectives

A. Minimize the rate of deterioration of buildings and structures and their integral systems and equipment.
B. Prevent deterioration of landscaped grounds below minimum acceptable visual and aesthetic levels.
C. Minimize the rate of deterioration of roads, walks, drives, parking lots, curbs and gutters, outside stairs, lagoon, fountain, signs, outside benches, and flagpoles.
D. Enhance facilities utilization.
E. Effectively accomplish construction, major repair, renovation, and alteration of facilities.
F. Effectively provide plant services to other university organizational elements.
G. Effectively provide and distribute all utilities.
H. Optimize support for special events.
I. Maximize operating cost-effectiveness.

Management This department is managed by the Director, Physical Plant Department. He or she usually reports to the Chief Business Officer.

Functional Responsibilities

Architecture and Engineering Services
Automotive Maintenance
Building and Equipment Maintenance
Construction, Major Repairs, Renovations, and Alterations
Construction Management
Estimating
Financial Management
Information Processing
Landscape Maintenance

Management Information Systems
Material Control
Personnel and Payroll
Physical Plant Services
Roads, Walks, and Grounds Maintenance
Utility and Energy Management
Utility Distribution
Work Control

Organizational Elements
Administrative Services Section
Architecture and Engineering Section
Construction Management Section
Maintenance, Service, and Operations Section
Utilities and Energy Management Section
Work Control Section

Staffing Satisfaction of Department responsibilities requires personnel with special skills too broad to list here. However, the spectrum ranges from entry-level, unskilled positions to manager and assistant director. The actual skills required, classifications and grades used, and numbers of persons utilized depends upon the scope and types of work required of this department at a particular time and within given budgetary constraints.

Functional Responsibilities: What Do We Do?

The chief business officer must decide which functions are to be assigned and included in the operation of the plant department. These functions should be distributed to, and understood by, the entire campus community. Does the institution have published statements of the plant functions, or have expectations developed by custom and usage?

All plant departments, regardless of size, have similar fundamental responsibilities. The basic functional responsibilities normally assigned to the plant department are administration, building maintenance, custodial services, utility systems and energy management, landscape and grounds maintenance, major repairs and renovation, and professional technical services.

Many institutions assign additional functions to the plant department such as a motor pool and/or automotive services, communications, safety and traffic, security, waste disposal, central stores, mail and messenger.

In order to manage effectively, the extent or scope of responsibility for the major functions should be formally documented. A management auditor will expect to see this documentation. Some selected examples follow. These are examples only and will vary from campus to campus.

Building Structures and Systems/Scope Totally responsible for maintaining and operating the campus buildings in a clean, comfortable, safe, and sanitary environment; for the physical conditions of the buildings at all times including major repairs, alterations, etc.; for maintaining and operating the electro/mechanical systems in a reliable condition free from interruptions. All this for the purpose of supporting the ongoing, day-to-day educational, research, and service missions of the institution.
Exceptions: List if applicable.

Campus Landscape and Grounds/Scope Totally responsible for maintenance, usability, and general appearance of the landscaped areas of the campus; irrigation systems; streets, driveways, and walks; grounds fixtures—pools, fences, benches, etc; and signs and graphics.

Utilities Systems/Scope Totally responsible for maintenance, operations, alterations, connections, expansions, load studies, demands, designs, locations, easements, and all pertinent records to assure continuous operations (as free from interruptions as possible).
Exceptions: Not included are telephone, television, computer, and microwave systems.

Energy Management/Scope Totally responsible for the purchase of electricity, natural gas, fuel oil, propane, water, and sewer services at the lowest possible rates for all facilities, including both state-supported and auxiliary facilities; for allocating all utility costs among the agencies; for reporting monthly utility rates and costs and future projections; for administering the energy savings and temperature regulations program; and for initiating modifications to energy systems that reduce consumption of all utilities.
Exceptions: Auxiliary enterprises administer their own energy savings and temperature regulation programs.

Professional Technical Services/Scope Totally responsible for development, design, contract document preparation, and contract administration of remodeling, major repair and replacement, major maintenance, facility management studies, and feasibility/budget studies of existing physical facilities. Totally responsible for design, analysis, contract document preparation, and contract administration of all repairs, additions, and new construction of utility systems.
Exceptions: Telephone, computer, and television cable and equipment, but including location and ductbank aspects of these systems.

Construction and Construction Management/Scope Totally responsible for coordination, scheduling, and construction of all project work (major repairs, alterations, etc.) in existing and occupied facilities. This includes all

in-house, departmental, and contracted workers. Assure compliance with codes, quality standards, plans and specifications, safety, as well as absolute minimum of disruption of ongoing activities.
Exceptions: Not included are auxiliary facilities and new major construction.

Services to Departments/Scope The plant department is staffed and organized to provide professional and technical talent for building utilities, equipment, and a multitude of special support services to all university departments. This includes in-house personnel as well as contracted services.

Campus Motor Pool/Scope Responsible for supplying the institution with high quality, well-maintained vehicles for official business; for providing bus service for large and small groups for both local and long distance trips.

Director's Responsibility and Authority

Many plant directors have a great deal of responsibility but little authority. It is important for a director to know and understand what his or her responsibilities and authority are.

Most plant directors report to the institution's chief business officer. The relationship between these two parties is paramount to managing a successful plant department. For this relationship to be optimal, the business officer should receive support from the plant director in the following ways:

- Loyalty and integrity. The business officer should never need to question the honesty, dedication, competence, or morals of the plant director.
- Up-to-date information. The business officer should be kept informed and never be surprised. He or she should hear news firsthand, rather than stumble upon it or hear it by the grapevine, thus creating an explosive situation.
- Good management of funds and good budget preparation. The plant director should be able to support and defend use of all funds. The director must maintain an awareness of the department's objective—to provide the facilities and environment to meet the institution's missions of teaching, research, and service. The director should be able to offer alternatives for doing the work, save money without sacrificing quality while remaining effective, and cope with price increases and budget reductions with innovation.
- Excellent management of personnel. The plant director must apply knowledge in labor relations, grievances and complaints, and career training to manage staff. He or she must organize people for the most efficient use of manpower.

- Professional and technical competence. Business officers often consider competence a director's top priority. In today's operation, competence as a *manager* takes priority over competence in engineering, architecture, or other technical areas. The director must remain current on new engineering and technical developments in facilities construction, maintenance, and operations in order to provide facilities that meet basic needs but consume a minimum of maintenance dollars.
- Decision-making capacity. The business officer needs to feel confident delegating a high level of decision making.
- Inventory. A perpetual inventory of facilities conditions should be kept, with a five-year program for restoring to original operating conditions or upgrading to meet all codes.

Equally important is the support the plant director must receive from the chief business officer. The most important areas are:

- Mutual trust. The business officer should demonstrate trust by delegating authority along with responsibility for accomplishing the facilities mission. The plant director must feel confident that he or she will be consulted in deliberations affecting management of plant services.
- Support. The business officer must understand and provide positive representation of plant needs for adequate compensation with sufficient responsibilities and professional challenge to attract and hold good personnel, adequate facilities and equipment to maintain plant facilities, adequate funding to operate and maintain the institution's facilities, and adequate funding to replace capital equipment.
- Assistance. The business officer should help establish, publish, and actively support the policies under which the plant department is to operate. He or she should also take an active role when violations of policies and procedures occur.
- Centralization. The business officer should channel all matters of physical change, operation, and maintenance through the plant department and request the director's input. Individual organizations that duplicate plant efforts should not be allowed throughout the institution. Overlapping services lead to confusion, conflict, and increased expense.
- Responsiveness. The business officer should provide a prompt response and make a sincere effort to give definite answers to problems in a timely fashion.
- Program review. The business officer should keep the plant director informed of annual and long-range projections of the institution's objectives and the physical plant's involvement. This

includes review of new programs, budgets, and ventures as they affect plant services.

- Periodic evaluation. To determine or measure the success or failure of the plant department in meeting its obligations, the business officer should conduct periodic evaluations. The business officer should also counsel the director when agreed upon objectives and goals are not met.

A formal job description specifies responsibilities and authority. It is a carefully written document rather than expectations developed through habit or happenstance. An example of a good job description for a facilities director follows:

AUTHORITY AND RESPONSIBILITIES
DIRECTOR, PHYSICAL PLANT DEPARTMENT

I. *Scope of Authority*

The director is granted broad authority to discharge his/her responsibilities. He/she is totally responsible for the operation of the plant department and makes decisions involving and encompassing the total department resources. The only limitations upon the exercise of this authority are those imposed by the chief business officer, university administrative policies, state fiscal rules, state personnel regulations, and ethical considerations.

II. *Principal Responsibility*

The Director, Plant Department, is responsible for directing, managing and administering department efforts associated with—

- Minimizing the rate of deterioration of buildings and structures and their integral systems and equipment.
- Preventing the deterioration of landscaped grounds below minimum acceptable visual and aesthetic levels.
- Minimizing the rate of deterioration of roads, walks, drives, parking lots, curbs, gutters, outside stairs, lagoon, fountain, signs, outside benches, and flagpoles.
- Enhancing facilities utilization.
- Effectively accomplishing construction, major repair, renovation, and alteration of facilities.
- Effectively providing services to other university organizational elements.
- Effectively providing and distributing utilities.
- Optimizing support for special events.
- Maximizing operating cost-effectiveness.

III. *Specific Responsibilities for Administration*

1. Identify and communicate departmental goals and objectives.

2. Prepare, implement, and update operating policies as required by goals and objectives.
3. Prepare procedures needed to support policy implementation.
4. Define responsibilities of subordinates and delegate required authority.
5. Correlate available funding with departmental objectives to determine resources (people, equipment, materials, etc.) and identify levels of effort to be applied.
6. Maintain a functional internal organization as dictated by departmental goals and objectives.

IV. *Planning*

1. Identify necessary changes in short-range goals and objectives, define action requirements, and implement.
2. Identify probable changes in long-range goals and objectives in order to adjust priorities and resource requirements.
3. Establish budget request limitations, prepare budget requests and justifications, and participate in presentations.
4. Define internal support requirements and provide appropriate resources.

V. *Control*

1. Monitor fiscal performance to ensure budget compliance, identify need for corrective action, and implement required changes.
2. Evaluate organizational performance in terms of quality of work, scheduling compliance, efficiency, etc., and define and implement required corrective action.

VI. *Personnel*

1. Establish and maintain effective performance evaluation system(s) for individuals.
2. Develop formal and informal programs for training, developing, and upgrading employees.
3. Identify normal career progressions for all entry-level classifications.
4. Develop and implement plans for maximizing promotional opportunities within the department.
5. Develop and implement ways of involving all affected personnel and clients in the decision-making process.

VII. *Communication and Coordination*

1. Maintain internal means of two-way communication as one basis for maximizing departmental effectiveness.
2. Maintain comprehensive regular contact with all university organizational elements concerning their needs for facilities support and monitor the relative satisfaction of these needs.

3. Advise superior of significant problems, developments, and achievements on a regular basis.
4. Participate in conferences, seminars, and professional organizations in order to improve the performance of the department.

[Note: The (1) mission, (2) assigned functions, and (3) responsibilities and authority assigned to the director are the key elements of an effective plant department. If the chief business officer has not identified these three elements, then the department is handicapped.]

Departmental Organization

There is no ideal organization for a physical plant department except the one that works for a particular institution at a particular time with particular people. Small plant departments may require no specialization beyond distinguishing key individuals' jobs from one another. As departments become larger and involved in more diverse activities, it becomes necessary to divide major tasks into division or section responsibilities.

The plant director must be responsible for dividing the work of the department into basic sections or divisions, defining responsibilities, and deciding who reports to whom. Since the plant department provides services to the entire campus, the campus community must understand how the organization works. Finally, the organizational structure must lend itself to budgetary control.

To evaluate a plant department, a formal structured and published organizational chart is important. The structure must be followed and established lines of communication should not be bypassed.

Plant Personnel

Physical plant departments require many different types of people with many different skills. The skills and abilities of these people determine the effectiveness of the department. Personnel are an organization's greatest resource. Three out of every four dollars (excluding purchased utilities) are paid for wages.

The professionalism shown by the director, staff, supervisors and artisans can visually and functionally enhance the image of the entire institution. Good supervisors and workmen are the foundation upon which a responsive and efficient department is built.

For these reasons the plant director must examine the training and development programs within the department. Is formal schooling encouraged? Does the department provide on-the-job training or is learning dependent on individual effort? What kind of training do employees receive before becoming first-line managers? Is an apprentice program in place? Auditors will ask these types of questions.

Budgeting for Plant Functions

A functional organization cannot be established or be operational without financial support. The plant department is not an independent or autonomous unit within the institution. It must share in the total budget. To attain necessary coordination between all departments, some budgetary policies must be established, published, and enforced by the chief business officer. Those affected must know who pays for what.

The plant department budget provides for maintenance of the basic building structures, public areas, general use areas, grounds, and utilities. In the academic and administrative buildings, the plant budget includes housekeeping, maintenance, and routine repairs; heating, ventilating, plumbing, and lighting; and maintenance of general classroom furniture.

Academic and administrative departments should recognize and budget for the costs associated with adapting spaces for specialized uses and for services required on items of their exclusive jurisdiction—special laboratory devices and apparatus and all special environmental conditions that the apparatus require. Academic and administrative budgets pay for the installation, repair, maintenance, and replacement costs of educational or research equipment required by the respective department.

Special activity budgets cover out-of-pocket expenses incurred to move equipment, set up chairs, provide public address systems, and make other arrangements resulting from the special needs of the activity in question. Charges include labor costs associated with parking attendants, offduty or overtime custodial services, and special utility requirements.

Auxiliary enterprises—intercollegiate athletics, bookstore, housing, food service, vending machines, audio-visual, printing services—and all self-sustaining service departments should pay their own operating maintenance costs (including utilities), since the objective is to operate on a self-sustaining basis covering all costs of operation.

Both financial and management auditors will review in detail who is paying for what kind of services. These policies should be developed in cooperation with the chief business officer.

Physical Plant Accounting System

Reliable cost information begins with individual workers and other costs are added to labor. The plant department consumes large resources in personal services (labor), operating supplies, shop machinery and tools, heavy equipment, vehicles, and other capital assets. The financial accounting system must provide financial information about the status and results of the department's use of resources.

The supervisory staff must know who is doing what where. The work order system drives the financial reporting system in the plant department.

The actual format of the work order system, therefore, must be tailored to particular campus needs.

Generally, the work order system is derived from the central accounting system of the institution. Through the use of electronic data processing (EDP) techniques, transactions in the work order system can be reported and balanced to the central accounting system. This provides a high degree of credibility in reports produced by a plant cost accounting system.

In addition to accounting for the distribution costs, the system also provides operating statistics useful to managers.

Cost control is another must in plant management today. Cost control requires establishing adequate accounting and reporting systems so that accurate costs are recorded and reported.

Plant Maintenance and Operations: How Well Do We Do It?

Two types of maintenance prevail: corrective and preventive maintenance. Corrective maintenance deals with problems after they occur and is a necessary part of any adequate maintenance program. However, when corrective maintenance (you break it-I fix it) comprises the institution's total program, it quickly leads to crisis maintenance—the most expensive kind of maintenance. Preventive mantenance, on the other hand, emphasizes finding and fixing potential problems before they disrupt operations. It is designed to minimize potential damage, reduce emergency overtime work, and eliminate exensive rush purchasing. A preventive maintenance program supports but does not eliminate the corrective program.

A management audit or self-evaluation will examine certain typical weaknesses. They include—

- No recognition of these two types of maintenance.
- Insufficient detail and follow-through in translating the concepts into operating programs.
- Inadequate planning, development, and documentation of operating programs.
- Inadequate training of personnel working in maintenance systems.

Correction of these weaknesses can increase productivity. The heart of an effective maintenance and operation program is the work order system. The system is designed to receive all work requests, initiate action, and follow the project through to completion. Without well-organized work order control, maintenance tasks do not begin promptly, are not completed properly, or are not recorded accurately. Improved response time, greater efficiency, smoother coordination, and better records for long-range planning result from an executive work order system. Good administrative procedures such as scheduling, estimating, coordinating, supervising, and record keeping are part of a well-planned work order system.

THE AUDIT REPORT

Plant managers should not expect a formal audit report to support or compliment carte blanche the total management of the department. The purpose of the audit is to seek the weakness in the organization and recommend strategies for improvement. Inefficiencies can be found in any organization, and there is always room for improving certain operations if one takes the time to evaluate them.

There should be no negative reaction to an audit, nor to any recommendations made for improvements, compliance with rules, policies, etc. Truly unfair criticism will eventually fade in the light of good performance.

When a formal management audit is made of the facilities department, the auditors first review their findings with the department's director. Although a few minor modifications or changes may result, the primary purpose is to avoid surprising the director when the final report is issued. The final report is usually presented by the auditor at a meeting with the requesting or authorizing administrator, the plant director, and others closely related to the audit. The published report is confidential and copies are issued only to the key personnel involved.

At this meeting the director is not expected to defend the organization and operations. This is the auditor's report. The director should ask for clarification or explanation of specific subjects in the report, but the director's action comes later.

Self-Study

Plant directors may wonder how they would rate on a management evaluation. Figure 6-1 is a do-it-yourself form listing a physical plant's major functions and levels of evaluation. To use the form, look at each function (or only the functions of particular interest) and circle the adjective that best describes how that function is carried out. Note that each level of evaluation—low, medium, high—offers two levels of "measurements."

After completing the checklist, directors and managers will be able to identify programs that are clearly successful and those that need attention and improvement. This form can easily be modified and adapted to specific situations.

Consultant Analysis

The plant director or someone higher in the institution's administration may decide to hire a consultant to conduct an audit of both fiscal and management activities. Such a study would include all or some of the functions listed in the following outline.

Physical Plant Management Audit Outline

I. Determine purposes and objectives of department.

  A. Review written policies and nonfinancial procedures.
    1. Do objectives communicated to staff agree with objectives as stated by the Board and administration?
    2. Are the written policies and procedures adequate to guide the department?
    3. Are policies and procedures realistic and attainable?

  B. Review significant programs the department handles.
    1. Are the programs clearly defined?
    2. Are goals set for the programs?

  C. Review higher level of authority's agreement with and opinion of the written goals and objectives.

II. Evaluate compliance with significant external regulations.

  A. Determine external regulators.

  B. Compile list of significant regulations with which physical plant should comply.

  C. Monitor compliance with significant regulations during field work.

III. Evaluate organizational structure and operational procedures.

  A. Organization.

    1. Prepare organization chart; enter names of incumbents.
    2. Examine job descriptions.
    3. Test qualifications of employees. Make general comparisons with written job descriptions.
    4. Evaluate distribution and adequacy of staffing. Review time-and-effort reports.
    5. Is span of command reasonable?
    6. Do supervisors perform physical labor or could they?
    7. Do all administrative positions serve a needed and useful purpose?

8. Is organization most efficient? Examine proposed organization chart.
9. Examine employee training programs at all levels.

B. Evaluate internal control.

1. Perform document and work flow review. Prepare appropriate flow charts.
2. Review and evaluate adequacy of appropriate financial procedures.
3. Discuss individual strengths and weaknesses of internal control system and give overall narrative ratings of internal controls.

C. Review architectural and engineering standards development.

1. What standards are followed by physical plant, e.g., industrial versus commercial? What is the difference?
2. Are standards comprehensive and adequately documented? Are they applied across-the-board or selectively? Are standards reasonable? What are the criteria for allowing deviations from the standard?
3. Are standards properly communicated to users, and in what way? When a department wants to remodel space, do plant personnel explain how standards must be maintained and the impact on costs?
4. Select several work projects (in-house and contracted) completed during the fiscal year for review.
    a) Visit departments and determine how standards were communicated to them.
    b) Determine if the department felt that standards were appropriate, too high, too low.
    c) If exceptions to the standards were allowed, what was the procedure for obtaining exceptions?
    d) Were exceptions documented and approved by appropriate plant personnel?
    e) Was supervision of the project adequate?
5. Are standards properly enforced?
    a) In-house construction.

        - (1) What quality controls exist?
        - (2) What processes assure that actual construction meets design standards?
    - b) Contracted construction.
        - (1) How are institutional standards communicated to the vendor? Are standards detailed before the contract is awarded?
        - (2) How does physical plant assure that the vendors meet standards? Outline the process.
        - (3) What leverage does the physical plant use to get vendors to correct deficiencies? Is the procedure consistently applied?

D. Review and evaluate decision rules for classifying maintenance work and projects by type and source of funding. Test application of these rules.

E. Evaluate trades operations.

1. Project management.
    - a) Evaluate organization.
    - b) Are planning, directing, execution, and control adequate?
    - c) Evaluate scheduling process.
2. Efficiency/effectiveness measures.
    - a) Compare in-house with contractor prices and quality. Determine if proper accountability and market incentives exist.
        - (1) Bids/estimates.
            - (a) Determine the procedure for developing estimates.
            - (b) Determine why estimates are used rather than bids.
            - (c) Obtain several estimates. Compare to actual. Note problem areas.
            - (d) Trace time reports. What kind of time reporting is required of plant employees?
            - (e) Determine break policies—length of breaks, lunch, quitting time? Are breaks, travel time, and returns to shop for tools included in actual labor costs?

      (f) What is the basis of contingency fees in estimates?
    (2) Compare physical plant bid to actual cost when work is contracted.
    (3) When vendors are used, identify role of physical plant in setting standards and specifications for bids and ensuring that work is done to specification.
    (4) Are plant management costs imposed on outside contractors reasonable?
  b) Is the work force (especially general laborers and trades helpers) tailored to current conditions to reduce labor expense?
    (1) How are the number and qualifications of people needed on projects determined?
    (2) Do current qualifications meet current needs?
    (3) What proportion of project labor costs is general (unskilled) labor? What proportion could be?
    (4) Is billing done with actual rather than appropriate rates?
  c) Survey customer satisfaction.

F. Maintenance operations.

1. Evaluate standard-setting process.
2. Review previous consulting study and implementation of recommendations
3. Evaluate decision rules for determining whether work is reimbursable or not.
4. Evaluate management of operations.
   a) Are planning, directing, controlling, and execution adequate (especially first-line supervision)?
   b) Survey customer/client satisfaction. Do customers know what service to expect? Is expected service delivered? How are complaints handled?
5. Arrange with selected building proctors to monitor custodial services during one month and compare with established plant standards.
6. Could custodial work begin during the day to reduce shift differential and allow custodians to meet people they're helping?

IV. Evaluate budgetary and expenditure control.

- A. Identify all financial resources available to the physical plant and the person(s) having expenditure control. Prepare trial balance(s).
- B. Determine how the detailed annual budget is developed.
  1. How are revenues estimated?
  2. Is funding allocated to programs? If so, how?
  3. How are expenses estimated?
  4. How are expenses allocated?
  5. Does the budget address *both* current year and long-term objectives of the department?
- C. Determine how effectively the budget is executed, controlled, and reported.
  1. Are expenditures and revenues properly coded?
  2. Does financial reporting facilitate budget control?
     - a) Identify reports (internal and external to physical plant).
     - b) Are reports useful, timely, and accurate?
  3. Is appropriate action taken on variations? Is accountability assigned and maintained?
- D. Determine if direct and indirect costs of programs are known and accurately reported. (See V.)
  1. Identify and schedule direct costs.
  2. Identify and schedule indirect costs. Exclude inventories. (See VII.B.)
     - a) Determine how the overhead rate was developed.
       - (1) Are all items included that should be?
       - (2) Are items included that should be a direct charge?
     - b) Are the percentages and formulas used reasonable and justifiable?
     - c) Examine the adequacy and correctness of the overhead rate.
  3. Are such expenses reasonable and complete?
  4. Analyze financial data.
     - a) Prepare and review three-year comparative balance sheet and income statements (standardized).
     - b) Prepare and review work order volume by trade.

c) Prepare and review trends in in-house versus contracted work.

d) Prepare and review trends in salaries—institution versus local market.

e) Prepare and review trends in ratio of support staff to workers.

f) Prepare and review trends in ratio of supervisors to nonsupervisors.

g) Prepare and review trends in project cost elements (labor, materials, overhead).

h) Obtain industry statistics on various norms, including work-time standards. Compare with actual operation.

i) Try to determine how much physical plant-related work may actually be performed by other departments (hidden physical plant costs). Why are these services provided by contractors or in-house staff?

j) Review rationale for assignment of revenues and expenses to the appropriated resident instruction funds versus the revolving funds.

5. Utilities.

a) Review last internal audit report and workpapers.

b) Evaluate expense distribution methods.

c) Review and evaluate energy conservation program.

d) Review long-range plans for providing uninterrupted, cost-effective utilities services.

V. Test revenue and expense transactions. (See IV.D.)

A. Select a sample of contracts/work orders for examination. Include some projects with multiple bids. (See III.E.2.a)(2).)

1. Review for proper authorization.

2. Evaluate reasonableness of financial (and other) details.

VI. Review equipment.

A. Examine the most recent equipment inventory performed by functional accounting. Are records up to date?

B. Examine policy on equipment usage (by whom? where? provisions for moving?)

C. Test from floor to records. Are all pieces of equipment properly recorded?

VII. Inventories.

A. Review the most recent functional accounting physical inventory and inventory workpapers.

B. How are inventory items issued and controlled?

1. Identify physical plant storeroom policies and procedures.
2. Determine the overhead rate applied to materials purchased through the storeroom.
3. Follow steps in IV.D.2.
4. Determine the policy, procedures, and charges associated with restocking materials.

C. Are all inventories recorded?

D. Are there any unreasonable overages or shortages? obsolete inventory?

VIII. Travel.

A. Select a sample of travel expenses from the department travel log.

B. Evaluate documentation for compliance and reasonableness.

IX. Investments and obligations.

A. Schedule and review investments and investment income for proper control and effective utilization.

B. Schedule and review long-term obligations and related expense for proper control and effective utilization.

Action Taken on an Audit Report

Audit reports, once made and accepted, require action by all parties listed in the report's recommendations. Where does the director begin? How will he or she get action?

First, the director and immediate staff or managers review the report in detail and discuss the merits of the numerous recommendations. Each recommendation in the report must be resolved. Adopt the "apple-pie-and-motherhood" suggestions without deliberation. Those recommendations requiring higher administrative action depend on that action, and the director should be prepared to influence those decisions/actions. Critical analysis of the remaining recommendations can be made by asking two basic questions:

- Does the recommendation make sense? (Including slight adaptations.)
- Is it practical, feasible, and economical to implement? (This depends greatly on available staffing and budget.)

Responding to an audit report is not a solo performance. Although directors must assume leadership and full responsibility, they must involve all levels of staff to work *with* them not *against* them. When and where credit is due, it must be acknowledged.

Do some critical thinking and analysis. Prepare a plan for action:

- What have we been doing the past five years? How well have we been doing it?
- What are we doing now?
- What are we going to be doing five years from now?

After thorough analysis, the director outlines the actions to be taken, probably in a priority listing with suggested dates for compliance. Sound justification should accompany the recommendations with which the director disagrees. Do not hesitate to disagree. But don't be defensive: be factual. Always establish dates for progress reports.

SUMMARY

There are no universal procedures for conducting formalized or periodic evaluations of a plant organization's effectiveness. Fiscal and financial audits are performed routinely and frequently, but in-depth management audits are rare. A facilities department is a group of people trying to operate an effective, timely, and economical support service for the broadly defined academic program of an institution. There is no best organizational structure, reporting relationship, or methodology. Therefore each management audit must be tailor-made for a particular plant department at a specific institution.

Management's role is getting done what needs to be done in and for the organization effectively, efficiently, and on a timely basis, subject to imposed restraints. Management's role is increasingly one of more active leadership and less headship (influence based on place in the organizational hierarchy). Managers at every level must do their jobs of managing. The organization and all the subunits must work together, under integrated manager-leadership, to bring about changes for optimum effectiveness and efficiency. Making the necessary changes to do a job effectively while optimizing personnel and employee satisfaction is a task of leadership. This type of manager-leadership can take an organization from average to good, and help it become excellent.

Basic management processes are two—intelligence and action, which are intertwined and interacting. To think and not act is futile. To act without thinking is ignorance. Thus, we *think* through objectives, standards, plans, programs, and procedures—the management process of planning, organizing, staffing, and control. Then we *implement* (act) the plans and programs through the management functions of *directions*.

Facilities directors must remember that the purpose of an audit is to help improve the management and organization of the physical plant department. Managers must be willing to ask, Will today's activities and methods be adequate in the next five years? The next ten years?

Figure 6-1

Facilities Management Profile

Function	**Levels of Evaluation**		
	Low	**Medium**	**High**
1. Mission of the Department	**Verbal** historical and traditional verbal to key staff	**Written** general guidance specific guidance	**Formal & Published** printed and published plus updating
2. Policies of the Department	**Verbal** custom and usage top-level instructions	**Incident Generated** general, written instructions specific, written statements	**Detailed Procedures** printed and published plus updating and contingent guidance
3. Responsibilities and Authority of Director	**Informal** report and act act and report	**Limited Formal** written job description written and detailed	**Formal** goals and objectives performance evaluations
4. Functional Organization of Staff	**Unstructured** verbal and assumed individual assignments	**Structured** general, written guidelines specific, written guidelines	**Structured & Controlled** printed, published & reviewed printed, plus contingent review
5. Personnel Organization of the Department	**Unstructured with Individual Assignment** craft shop	**Structured** craft or shop function	**Structured & Controlled** printed chart charted and written job duties

	None		**Informal**		**Formal**	
6. Personnel Training and Career Development	none	individual effort	on-the-job training		formal, classroom	career ladder
	Informal		**Formal**		**Detailed & Controlled**	
7. Budgeting	assigned	record expenditures	historical cost basis	supported appropriations	control forecast for level of maintenance	planning, programming, and control
	Informal		**Formal**		**Detailed & Controlled**	
8. Financial Management	salaries and expenses	record of expenditures	general accounting reports	cost-center reports	management information	decision and forecasting data
	Verbal		**Written**		**Formal & Published**	
9. Maintenance	breakdown	haphazard	scheduled by craft	plus backlog control	comprehensive preventive maintenance	plus computerized maintenance engineering
	Family Style		**Informal**		**Reception & Control**	
10. Work Request	individual worker	staff and supervisor	departmental verbal request	day-shift answering service	written record and feedback	three-shift receptionist and response
	Unplanned		**Simple Standards**		**Planned**	
11. Work Identification	complaints and emergencies	routine requests	manufacturing and safety standards	scheduled inspections	planned and scheduled inspections based on standards	computerized, plus engineering

	Verbal		**Informal**		**Formal Authority**	
12. Work Authorization	customer	staff or shop	standing or regular work order	supervisors approve specific work orders	specific work order approval by staff	specific work order approval by director
	No Standards		**Experience Standards**		**Formal Standards**	
13. Planning and Estimating Work	magnitude by foreman	rule of thumb	shop experience	group experience by staff	engineered performance	published standards
	Informal		**Partial Formal**		**Scheduled & Formal**	
14. Work Scheduling	none	by trade	major work scheduled	preventive maintenance scheduled	in-house force and contract work	scheduling engineering
	Informal		**Simple Control**		**Detailed Evaluation**	
15. Employee Work Performance	visual	routine checking	supervisors review	staff analysis compared to standards	work sampling and charting	value analysis
	Informal		**Formal**		**Detailed Evaluation**	
16. Departmental Evaluation and Analysis	complaints	cost based on square footage	written reports	personal involvement	detailed performance analysis	management audit

PART VII

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